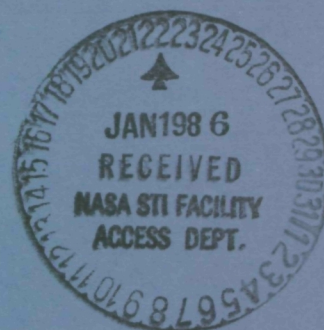


# NASA

Aeronautical  
Engineering  
A Continuing  
Bibliography  
with Indexes

NASA SP-7037(193)  
November 1985

National Aeronautics and  
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Accession numbers cited in this Supplement fall within the following ranges.

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# AERONAUTICAL ENGINEERING

## A CONTINUING BIBLIOGRAPHY WITH INDEXES

(Supplement 193)

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced in October 1985 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*



Scientific and Technical Information Branch

1985

**National Aeronautics and Space Administration**

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# INTRODUCTION

This issue of *Aeronautical Engineering -- A Continuing Bibliography* (NASA SP-7037) lists 682 reports, journal articles, and other documents originally announced in October 1985 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA)*.

The coverage includes documents on the engineering and theoretical aspects of design, construction, evaluation, testing, operation, and performance of aircraft (including aircraft engines) and associated components, equipment, and systems. It also includes research and development in aerodynamics, aeronautics, and ground support equipment for aeronautical vehicles.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged by the first nine *STAR* specific categories and the remaining *STAR* major categories. This arrangement offers the user the most advantageous breakdown for individual objectives. The citations include the original accession numbers from the respective announcement journals. The *IAA* items will precede the *STAR* items within each category.

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An annual cumulative index will be published.



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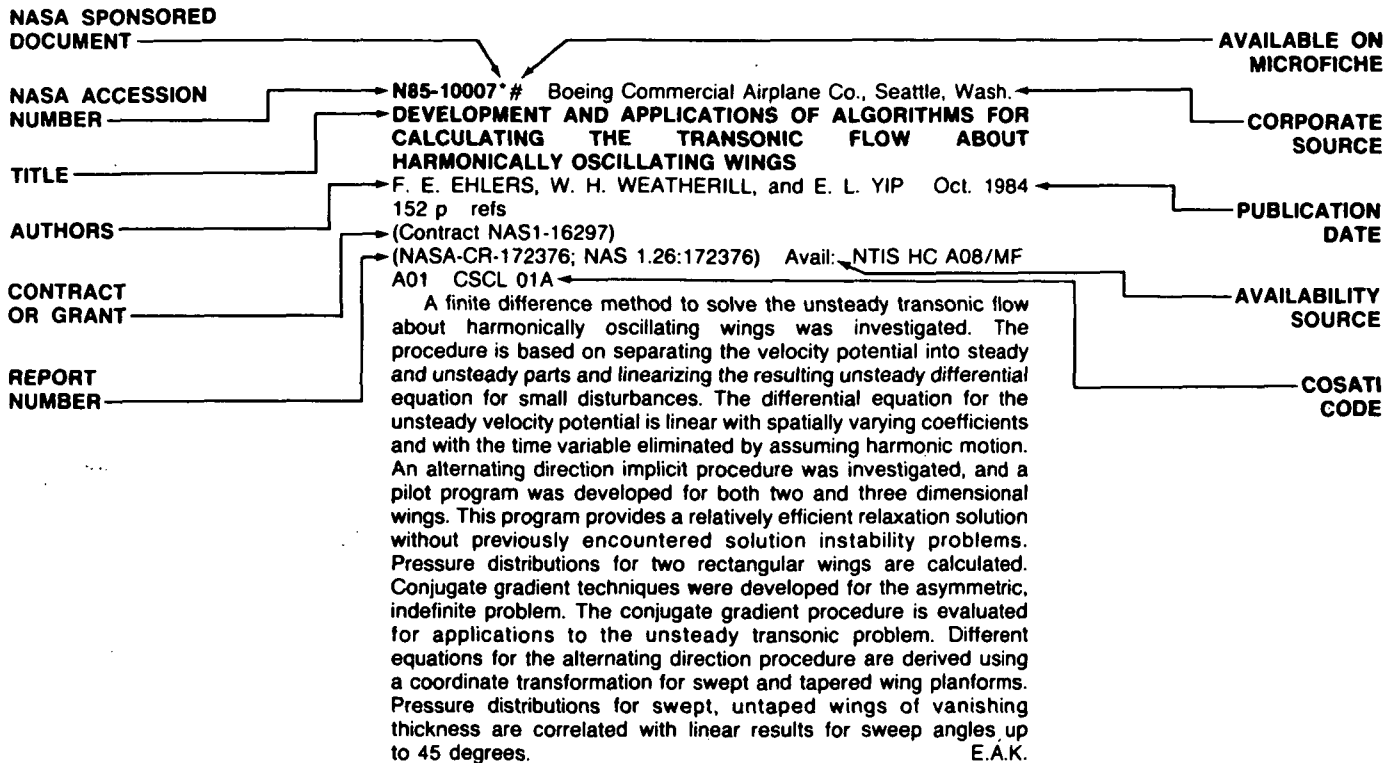


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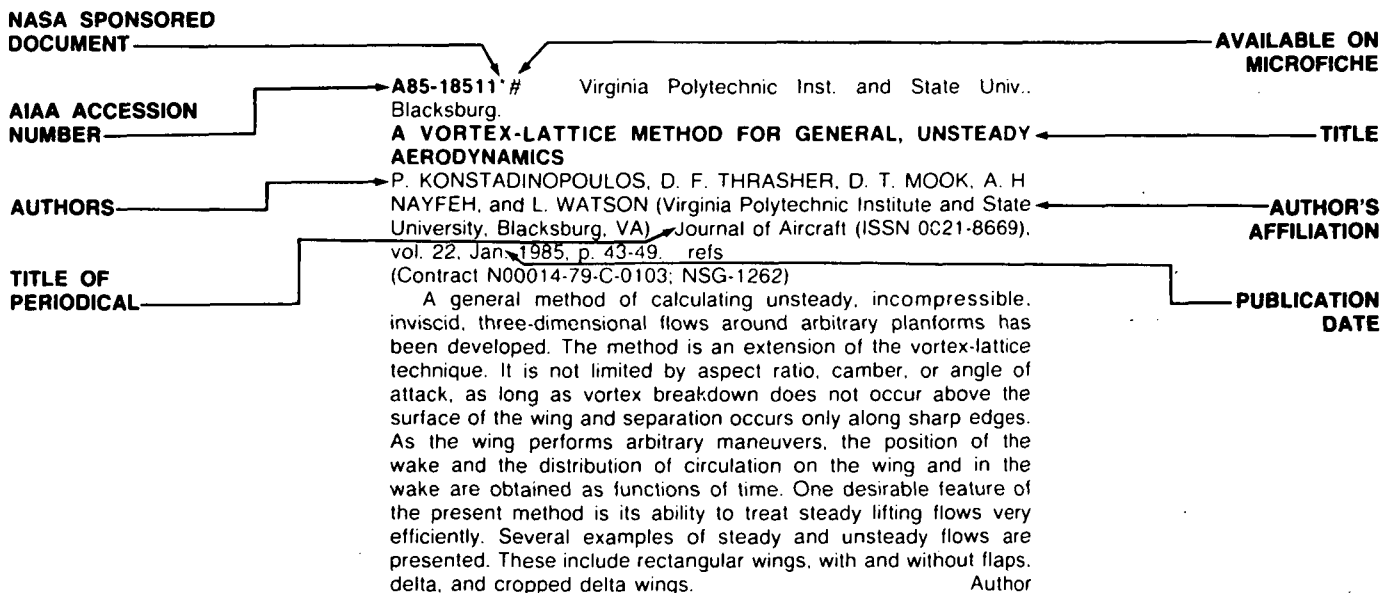
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# AERONAUTICAL ENGINEERING

*A Continuing Bibliography (Suppl. 193)*

NOVEMBER 1985

01

## AERONAUTICS (GENERAL)

**A85-40290#**

### **APPLICATION POSSIBILITIES FOR TRANSPORT HELICOPTERS [EINSATZMOEGlichkeiten FUER TRANSPORTHUBSCHRAUBER]**

F. MUSMAN (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) DGLR and DGON, Symposium ueber die allgemeine Luftfahrt und Regional Luftverkehr-Bestandteile des Verkehrssystems, Friedrichshafen, West Germany, Mar. 26-29, 1985, Paper. 18 p. In German.

The current status of the world market for large (3-9-tonne) civilian helicopters is surveyed, with specific reference to developmental efforts underway at MBB. The currently marketed transport helicopters and their typical applications are summarized in a chart and discussed; the design tradeoffs between helicopter stability and maneuverability are examined; the mission-specific optical equipment required by most potential customers is listed; and photographs of the exteriors and interiors of MBB helicopters are provided. T.K.

**A85-40293#**

### **SIMPLE AIRCRAFT [EINFACHFLUGZEUGE]**

K. KOPLIN (Luftfahrt-Bundesamt, Brunswick, West Germany) DGLR and DGON, Symposium ueber die allgemeine Luftfahrt und Regional Luftverkehr-Bestandteile des Verkehrssystems, Friedrichshafen, West Germany, Mar. 26-29, 1985, Paper. 8 p. In German.

The development and regulation of simple aircraft (SA), defined as a new class between ultralight aircraft on the one hand and normal aircraft or power gliders on the other, are discussed from the perspective of a West German federal aviation official. The role of future SA in lowering the cost of private flight training and sport flying is indicated; the French avion tres leger and the U.S. Primary Aircraft or Personal Use Aircraft programs are briefly examined; the history of efforts to define regulations and certification requirements for France, the U.S., and Europe is recounted; and the willingness of the West German authority to grant special certification to experimental SA prototypes prior to the formulation of regulations is emphasized. T.K.

**A85-40294#**

### **COORDINATION OF DIFFERENT TYPES OF AIR TRAFFIC [ZUSAMMENWIRKEN UNTERSCHIEDLICHER FLUGBETRIEBSARTEN]**

W. TRINKAUS (AOPA - Germany Verband der allgemeinen Luftfahrt, Egelsbach, West Germany) DGLR and DGON, Symposium ueber die allgemeine Luftfahrt und Regional Luftverkehr-Bestandteile des Verkehrssystems, Friedrichshafen, West Germany, Mar. 26-29, 1985, Paper. 10 p. In German.

The transportation services provided by light private, business, and commercial aircraft are characterized in a general review based on the case of West Germany. Several examples demonstrating that light aircraft using simple airfields are often the most

economical means of transportation for business personnel, both between regional and international airports and for point-to-point travel within West Germany, are presented, and some of the problems involved in coordinating light-aircraft and commercial-jet traffic at larger airports are discussed. T.K.

**A85-40301#**

### **NEW CONFIGURATIONS AND THEIR CONTRIBUTION TO THE REDUCTION OF COMMERCIAL-AIRCRAFT OPERATING COSTS [NEUE KONFIGURATIONEN UND IHR BEITRAG ZUR REDUZIERUNG DER BETRIEBSKOSTEN VON VERKEHRSFLUGZEUGEN]**

H. G. KLUG (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 61 p. In German. refs  
(DGLR PAPER 84-081; MBB-UT-03-84)

Recently proposed new commercial-aircraft configurations, mainly for very large aircraft, are surveyed and illustrated with drawings and graphs of predicted performance. Consideration is given to strut-supported wings; multiple fuselages; wing-fuselage integration; very long wings; canard configurations; natural-laminarity wings; and propane, liquid-hydrogen, and atomic propulsion systems. Given the conservative nature of current aircraft design, a slow evolution toward some of these unusual configurations is predicted. T.K.

**A85-40338#**

### **SHORT-RANGE ANTIARMOR FLIGHT VEHICLES OF THE APACHE/CWS FAMILY [SHORT RANGE FLUGKOEPPER ZUR PANZERBEKAEMPFUNG AUS DER APACHE/CWS FAMILIE]**

D. WEIDENHAGEN (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 18 p. In German.  
(DGLR PAPER 84-125)

The present status and new developments regarding the MW-1 dispenser and submunitions technology are discussed. The multipurpose MW-1 system represents one of the weapons systems used for the military aircraft Tornado. The ejection procedure MW-1 utilizes a central gas generator. The employment of a rocket engine makes it possible to reduce the width of a dispenser significantly. Attention is given to an ejection procedure with ejection velocities up to 75 m/sec, involving the employment of MW-1 submunition. The effectiveness of this procedure was demonstrated in the joint U.S.-West German Low Altitude Dispenser program in 1984. A description is provided of a weapons family which can be established on the basis of new technological developments. Approaches for using flight vehicles in antiarmor warfare are considered along with mines equipped with acoustic sensors, details regarding the modular concept of the Apache/CWS system, and the conduction of missions against armored vehicles. G.R.

## 01 AERONAUTICS (GENERAL)

**A85-40346#**

**REQUIREMENTS FOR FUTURE AIRCRAFT PROGRAMS FROM THE PERSPECTIVE OF AN AIRLINE COMPANY IN INTERNATIONAL COMPETITION [ANFORDERUNGEN AN ZUKUNFTIGE FLUGZEUGPROGRAMME AUS DER SICHT EINER FLUGGESELLSCHAFT IM INTERNATIONALEN WETTBEWERB]**

R. ABRAHAM (Deutsche Lufthansa AG, Cologne, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984, Paper. 25 p. In German.

The process by which commercial transport aircraft are developed and marketed is examined critically from the point of view of the airline companies, and strategies for improving the process are proposed. Problems discussed include the sometimes extravagant demands of airline companies, the lack of coordination among airlines in influencing aircraft design, the fact that many performance improvements increase the initial cost of an aircraft so much that fuel or time savings are cancelled out, inadequate market analysis on the part of manufacturers, leap-frog competition practices involving only marginal improvements, and the failure of conventional financing schemes to meet the very high capital needs of the industry. The need for aircraft of smaller capacity for short, medium, and long hauls is indicated, and some financial involvement of airlines in the development process is recommended. T.K.

**A85-40461#**

**STRUCTURES IN SERVICE - AN AIRLINE POINT OF VIEW**

R. L. ELVIDGE (Air Canada, Montreal, Canada) (Canadian Aeronautics and Space Institute, Annual General Meeting, 31st, Ottawa, Canada, May 28, 29, 1984) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 30, Dec. 1985, p. 354-362.

Because airframe structures in airline service suffer various kinds of degradation throughout their lives, a detailed maintenance program is required in order to ensure that aircraft can be safely operated for an extended period of time. Maintenance program revisions must be undertaken in cooperation with the manufacturer and airworthiness authorities as an aircraft ages, balancing continued safety against costs incurred by the airline. Attention is presently given to a formalized approach for the detection and prevention of structural degradation which encompasses inspection and active corrosion inhibition, as well as to aircraft damage types and the repair techniques that have been developed for them to date. O.C.

**A85-40536**

**HELICOPTER AIR-TO-AIR FROM THE R&D PERSPECTIVE**

C. E. HAMMOND and N. C. KAILOS (U.S. Army, Applied Technology Laboratory, St. Louis, MO) Vertiflite (ISSN 0042-4455), vol. 31, July-Aug. 1985, p. 56-60.

It is pointed out that the issue of air-to-air combat between helicopters is one which is receiving increased attention in all countries involved in the development of helicopters. However, it has been found that no engineering data exists on the subject. For this reason, the Applied Technology Laboratory (ATL) of the U.S. Army Aviation Systems command initiated a multifaceted program to evaluate current capabilities and to determine those areas which require research and development efforts to fill technology gaps. The conducted program may be divided into two parts, including a part which deals with elements and issues related to air vehicle capabilities and another part addressing weaponization issues. Details regarding these two parts are discussed. G.R.

**A85-40537**

**AIR TRANSPORT DEVELOPMENT VENTURES**

R. W. RUMMEL Society of Automotive Engineers, William Littlewood Memorial Lecture, 11th, Long Beach, CA, Oct. 17, 1984. 21 p. refs (SAE PAPER 841628; SAE SP-601)

An historical account is given of the U.S. airline industry's growth through the incorporation of novel transport aircraft technology,

from the inception of the DC-1 airliner to the present. The extremely rapid pace of the introduction of new aircraft designs prior to the introduction of jet propulsion is noted, and attention is given throughout to the specific case of Trans World Airlines, as it expanded in the course of the period discussed from a North America to a global airline service. The author of the present account was assigned to duties of aircraft evaluation, fleet planning, aircraft specification and emerging technologies' appraisal. O.C.

**A85-40842#**

**BIONIC BAT - STORED ENERGY HUMAN POWERED AIRCRAFT**

M. B. COWLEY, W. R. MORGAN (AeroVironment, Inc., Simi Valley, CA), and P. MACCREADY (AeroVironment, Inc., Monrovia, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 12 p. refs (AIAA PAPER 85-1447)

The 'Bionic Bat', which currently holds the world's speed record for human-powered aircraft, augments the energy generated by the pilot during flight by means of stored energy generated during the 10 minutes immediately prior to takeoff, as permitted by the Kremer World Speed Competition rules. This electrical energy storage system comprises a DC motor/generator and a battery of 16 Ni-Cd rechargeable cells having 50 percent discharge efficiency, for a total storage system efficiency of about 20 percent. O.C.

**A85-40902**

**CHINESE DESIGN SUPERSONIC BOMBER, PLAN JOINT EFFORTS TO BUILD MOMENTUM**

C. COVAULT Aviation Week and Space Technology (ISSN 0005-2175), vol. 123, July 15, 1985, p. 61-63; 66.

Recently announced research, development and production plans for the aerospace industry of the People's Republic of China are discussed. Attention is given to the design details and commercial prospects of the B 707-like Y-10 four-engine airliner, which incorporates novel wing airfoil and leading edge slat designs and electrically actuated landing gear. Plans are noted for the development of a twin engine supersonic bomber, as well as for the manufacture of the Soviet An-24-based Y-7 turboprop-engined airliner. O.C.

**A85-41317#**

**AEROSPACE DESIGN AND PROJECTED DEFENCE POLICY**

J. PAGE ADIU Report (ISSN 0264-0643); vol. 6, Sept.-Oct. 1984, p. 8-10.

In western nations, the type of products ordered by government agencies are subject to the decisions of the political party holding office. The controlling party may change in the interval from design to production status. Multinational efforts, such as those arranged to develop the European Fighter Aircraft, tend to remove the projects from political changes and lessen democratic control over the process. The richest nations will purchase aircraft close to the state of the art in technology, while poorer nations may only have the option of buying less advanced, less capable models. Still, the state of the art aircraft must have design flexibility to accommodate further upgrades while in service. A recurring problem is that the flexibility must extend to a service life that begins 10 yr after initiation of the design process. M.S.K.

**A85-41734**

**DEHUMIDIFICATION AS A MEANS OF PREVENTING ATMOSPHERIC CORROSION IN AIRCRAFT ENGINES AND AVIONIC SYSTEMS**

International Journal of Aviation Safety (ISSN 0264-6803), vol. 3, June 1985, p. 148-150.

Dehumidifying systems are being extensively used by the Danish and Swedish air forces, in order to exploit the fact that metallic and electronic aircraft components' corrosion does not occur when relative humidity is lower than 50 percent. Dramatic improvements are noted in the MTBF statistics of Swedish Air Force radar and cabin instruments, and the Danish Air Force has reported a complete absence of turbine engine component corrosion since the installation of dehumidifiers. All Swedish operational aircraft

are now housed in hangars with central dehumidification equipment. O.C.

**A85-43190#****MODERNIZATION IN AEROSPACE**

H. F. ROGERS (General Dynamics Corp., Fort. Worth, TX) IN: White-collar productivity and quality issues; Proceedings of the Symposium on Productivity and Quality: Strategies for Improving Operations in Government and Industry, Washington, DC, September 25, 26, 1984. New York, AIAA, 1985, p. 91-94.

The implementation of technological innovations to increase productivity in the development and manufacture of aircraft is discussed using examples from the F-16 program. It is pointed out that the number of man-hours required to produce an F-16 has decreased from 110,000 in 1979 to less than 30,000 in 1983, with a concomitant increase in the proportion of defect-free aircraft (from 39 to over 50 percent) and substantial savings for both manufacturer and DOD. Specific measures examined include involvement of subcontractors in the technology-modernization program initiated by the Air Force, introduction of the electrical-harness data system, implementation of robotics, office automation, increased use of CAD/CAM, improved computer communications between engineering departments and factory floor, and installation of material-requirements and manufacturing-resource planning programs. T.K.

**N85-29912\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**PRESSURE DISTRIBUTION DATA FROM TESTS OF 2.29 M (7.5 FEET) SPAN EET HIGH-LIFT TRANSPORT AIRCRAFT MODEL IN THE AMES 12-FOOT PRESSURE TUNNEL**

S. O. KJELGAARD and H. L. MORGAN, JR. Apr. 1983 671 p refs

(NASA-TM-84517; NAS 1.15:84517) Avail: NTIS HC A99/MF A01 CSCL 01B

A high-lift transport aircraft model equipped with full-span leading-edge slat and part-span double-slotted trailing-edge flap was tested in the Ames 12-ft pressure tunnel to determine the low-speed performance characteristics of a representative high-aspect-ratio supercritical wing. These tests were performed in support of the Energy Efficient Transport (EET) program which is one element of the Aircraft Energy Efficiency (ACEE) project. Static longitudinal forces and moments and chordwise pressure distributions at three spanwise stations were measured for cruise, climb, two take-off flap, and two landing flap wing configurations. The tabulated and plotted pressure distribution data is presented without analysis or discussion. Author

**N85-29913#** Naval Postgraduate School, Monterey, Calif. **THE EVOLUTION OF THE U.S. HELICOPTER INDUSTRY M.S. Thesis**

M. D. SHEIL Dec. 1984 249 p (AD-A154290) Avail: NTIS HC A11/MF A01 CSCL 05C

The first production helicopter in the United States was produced by Sikorsky Aircraft (now a division of United Technologies) in 1941 as a direct result of a U.S. Army Air Corps requirement. Helicopter technology advanced rapidly, driven mainly by U.S. Department of Defense research and developmental funding. The business code expanded as commercial operators became more aware of helicopter capabilities made available through advancing technology. Many competitors were attracted to the industry, including a number from overseas. This thesis examines the growth of the U.S. helicopter industry and explores the issues that have led to the success or failure of the industry's competitors. A particular issue addressed is the role the Department of Defense has played in shaping the industry. The work concludes with an analysis of the current state of the industry and the prospects for its future. GRA

## 02

## AERODYNAMICS

Includes aerodynamics of bodies, combinations, wings, rotors, and control surfaces; and internal flow in ducts and turbomachinery.

**A85-40302#**

**AERODYNAMIC-DESIGN TRENDS FOR COMMERCIAL AIRCRAFT [AERODYNAMISCHE ENTWICKLUNGSRICHTUNGEN FÜR VERKEHRSFLUGZEUGE]**

R. HILBIG (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) and H. KOERNER (DFVLR, Institut fuer Entwurfs-Aerodynamik, Brunswick, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 53 p. In German. refs (DGLR PAPER 84-082)

Recent research on advanced-configuration commercial aircraft at DFVLR is surveyed, with a focus on aerodynamic approaches to improved performance. Topics examined include transonic wings with variable camber or shock/boundary-layer control, wings with reduced friction drag or laminarized flow, prop-fan propulsion, and unusual configurations or wing profiles. Drawings, diagrams, and graphs of predicted performance are provided, and the need for extensive development efforts using powerful computer facilities, high-speed and low-speed wind tunnels, and flight tests of models (mounted on specially designed carrier aircraft) is indicated. T.K.

**A85-40316#**

**THE WORKING GROUP ON DETACHED FLOWS - NEW IMPULSES FOR FLOW RESEARCH AND AERODYNAMICS [ARBEITSGEMEINSCHAFT 'STROEMUNGEN MIT ABLOESUNG' - NEUE IMPULSE FÜR DIE STROEMUNGSFORSCHUNG UND AERODYNAMIK]**

H.-G. KNOCH (Messerschmitt-Boelkow-Blohm GmbH, Ottobrunn, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 53 p. In German. (DGLR PAPER 84-097)

Recent West German research on flows with separation is surveyed with a focus on activities of the working group on detached flows (German designation STAB) established in 1979 to coordinate industry, government, and university efforts and identify applications-oriented research goals. The history of STAB is traced; the organizational structure and operating procedures are described; and the work of the four STAB project groups (large-aspect-ratio wings, small-aspect-ratio wings, rotors, and flight-bodies/fuselages) and the five STAB subject-area groups (physical bases and mathematical bases of detached flows, numerical simulation, measurement technology, and facilities) is examined and illustrated with photographs, graphs, drawings, and tables. T.K.

**A85-40328#**

**THE REPRESENTATION OF AIRCRAFT-EXTERNAL STORE-INTERFERENCES UNDER SUPERSONIC CONDITIONS [DARSTELLUNG VON FLUGZEUG/AUSSENLAST-INTERFERENZEN IM ÜBERSCHALL]**

R. DESLANDES (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 23 p. In German. (DGLR PAPER 84-112)

The importance of supersonic missions for modern fighter aircraft increases continuously, and an aerodynamic integration of external stores becomes vital. Such stores can include fuel tanks and air-to-air missiles. An optimal design and the development of the involved components must be based on an accurate knowledge regarding the flow around the considered configuration. Interference



## 02 AERODYNAMICS

effects arising in the case of the external store-aircraft configuration are related to the external flow around the aircraft with the existing shock fronts, detached shocks at the external store, embedded subsonic fields, and shock reflections between external store and aircraft. Attention is given to the aerodynamic and numerical problems, advantages of the zonal decomposition approach, the method employed for the solution of the obtained system of partial differential equations, the computational grid developed for the employment of the finite-volume procedure, and computational results which describe the interference effects. This study indicates an approach for quantifying the considered interferences. G.R.

**A85-40342#**

### UNSTEADY AERODYNAMICS ON THE ZKP LARGE-SCALE MODEL AS A RESULT OF RAPID CONTROL-SURFACE MOTION [INSTATIONÄRE AERODYNAMIK AM ZKP-GROSSMODELL INFOLGE SCHNELLBEWEGTER STEUERFLÄCHEN]

S. VOGEL (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) and H. SCHAEFER (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 34 p. In German. BMFT-supported research. refs (DGLR PAPER 84-130; MBB-UT-08-84)

The results of unsteady pressure-distribution measurements on a modified version of the 4-m-half-wingspan DKP half-model (a supercritical wing developed for the A 310, with three spoilers, one aileron, and one flap) performed in the S1 transonic wind tunnel at ONERA Modane at Mach 0.5-0.83, angle of attack from -1 to +3 deg, excitation frequency 6-21 Hz, and excitation amplitude 1-2 deg are presented in extensive graphs and discussed. Included are steady pressure-distribution and hinge-moment determinations, balance measurements, and unsteady measurements involving harmonic, white-noise, and ramp-signal excitation of the control surfaces. These experiments are part of a program to improve maneuvering ability and reduce gust loading in commercial transport aircraft. T.K.

**A85-40682\*#** Jet Propulsion Lab., California Inst. of Tech., Pasadena.

### WIDE-FIELD SHADOWGRAPH FLOW VISUALIZATION OF TIP VORTICES GENERATED BY A HELICOPTER ROTOR

S. P. PARTHASARATHY, Y. I. CHO, and L. H. BACK (California Institute of Technology, Jet Propulsion Laboratory, Pasadena) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 11 p. refs (Contract NAS7-918) (AIAA PAPER 85-1557)

The vortex trajectory and vortex wake generated by helicopter rotors were visualized using a wide-field shadowgraph technique. Use of a retro-reflective Scotchlite screen made it possible to investigate the flow field generated by full-scale tail rotors. Tip vortex trajectories were visible in shadowgraphs for a range of tip Mach number of 0.38 - 0.60. The effect of the angle of attack was substantial. At an angle of attack greater than 8 degrees, the visibility of the vortex core was significant even at relatively low tip Mach numbers. The theoretical analysis of the visibility was carried out for a rotating blade. This analysis demonstrated that the visibility decreases with increasing dimensionless core radius ( $r_0/c$ ) and increases with increasing tip Mach number. Based on this investigation, it is concluded that the wide-field shadowgraph flow visualization technique should be feasible to study the flow field generated by a large main rotor in a wind tunnel and in an outdoor full-scale test stand. Of note is that the shadowgraph technique could easily be used with other on-going tests such as aerodynamic performance study, noise measurements, velocity measurements with LDV or hot-wire anemometer, local pressure measurement on the rotor surface, etc. Author

**A85-40683\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### MEASUREMENT AND PREDICTION OF MODEL-ROTOR FLOW FIELDS

F. K. OWEN and M. E. TAUBER (NASA, Ames Research Center, Moffett Field, CA) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July, 16-18, 1985. 17 p. refs (AIAA PAPER 85-1558)

This paper shows that a laser velocimeter can be used to measure accurately the three-component velocities induced by a model rotor at transonic tip speeds. The measurements, which were made at Mach numbers from 0.85 to 0.95 and at zero advance ratio, yielded high-resolution, orthogonal velocity values. The measured velocities were used to check the ability of the ROT22 full-potential rotor code to predict accurately the transonic flow field in the crucial region around and beyond the tip of a high-speed rotor blade. The good agreement between the calculated and measured velocities established the code's ability to predict the off-blade flow field at transonic tip speeds. This supplements previous comparisons in which surface pressures were shown to be well predicted on two different tips at advance ratios to 0.45, especially at the critical 90 deg azimuthal blade position. These results demonstrate that the ROT22 code can be used with confidence to predict the important tip-region flow field, including the occurrence, strength, and location of shock waves causing high drag and noise. Author

**A85-40685#**

### AERODYNAMICS OF TWO-DIMENSIONAL BLADE-VORTEX INTERACTION

G. R. SRINIVASAN (JAI Associates, Mountain View, CA), W. J. MCCROSKEY, and J. D. BAEDER (U.S. Army, Aviation Research and Technology Activity, Moffett Field, CA) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 20 p. refs (Contract DAAG29-85-C-0002) (AIAA PAPER 85-1560)

Numerical procedures are developed for calculating flowfield interactions arising when a forward-moving helicopter blade encounters a passing vortex. The flowfield is treated as being two-dimensional and unsteady, requiring the implicit solution of thin-layer Navier-Stokes equations using a perturbation approach. Sample results in subsonic and transonic conditions illustrate the model's capability of handling a wide range of shapes and sizes of the interacting vortex. Several aspects of subcritical and supercritical situations are revealed by the calculations and are discussed. M.S.K.

**A85-40686#**

### VORTEX PANEL CALCULATION OF WAKE ROLLUP BEHIND A LARGE ASPECT RATIO WING

D. T. YEH and A. PLOTKIN (Maryland, University, College Park) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 12 p. Army-supported research. refs (AIAA PAPER 85-1561)

A higher-order (linear vortex) panel method is used to calculate the three-dimensional wake rollup behind large aspect ratio symmetric wings in steady inviscid incompressible flow. Triangular shaped panels are chosen to increase the geometric flexibility of the wake sheet. The wing spanwise circulation distribution is obtained from lifting line theory and the wake geometry is then evaluated in an iterative fashion by satisfying conservation of circulation, flow tangency as well as zero pressure jump for all wake panel surfaces in the near wake region (two spans in length). The far wake is modeled by straight semi-infinite vortex filaments that are in the uniform stream direction. Numerical results are shown to compare favorably with those in the literature. The capability of the method to model a rectangular wing with a deflected flap is also studied. Author

A85-40687#

**PRESSURE FLUCTUATIONS IN A  
THREE-DIMENSIONAL SHOCK WAVE/TURBULENT  
BOUNDARY LAYER INTERACTION AT VARIOUS SHOCK  
STRENGTHS**

D. K. M. TAN, S. M. BOGDONOFF (Princeton University, NJ), and  
T. T. TRAN American Institute of Aeronautics and Astronautics,  
Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th,  
Cincinnati, OH, July 16-18, 1985. 13 p. refs  
(Contract F49620-84-C-0086)  
(AIAA PAPER 85-1562)

This paper presents results of fluctuating surface pressure measurements in a three-dimensional shock wave/turbulent boundary layer interaction at various shock strengths. The shock was generated by a sharp-edged fin set perpendicular to the boundary layer. Fin angles of 12, 16, and 20 deg were tested at a nominal Mach number of 2.95 and a unit Reynolds number of 72 million/m. The distribution of normalized rms pressure immediately downstream of the start of the interaction shows the evolution of a peak whose magnitude increases with shock strength. The peak value, however, is only half that for a two-dimensional compression ramp interaction with a similar strength shock. Examination of time traces shows an intermittent region at the start of the interaction. Measurements of space-time correlation and cross-spectra in this region indicate that the intermittent behavior is caused by the unsteady nature of the shock structure of the interaction.

Author

A85-40688#

**EVALUATION OF EULER AND NAVIER-STOKES SOLUTIONS  
FOR LEADING-EDGE AND SHOCK-INDUCED SEPARATIONS**

K. FUJII (National Aerospace Laboratory, Chofu, Japan) and S.  
OBAYASHI (Tokyo, University, Japan) American Institute of  
Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics  
and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985.  
17 p. refs  
(AIAA PAPER 85-1563)

Euler and thin-layer Navier-Stokes (TNS) equations are used to model vortical flowfields over conical delta wings in order to test the reliability of the Euler equations in separation conditions. The Euler equation fails to predict the location of the cross-flow shock wave, while the TNS yields acceptable results. The Euler equation does indicate the occurrence of shock-induced separation near the leading edge, downstream of the shock and in a region with an entropy gradient. The separation is noted also to be caused by numerical dissipation when the gradient is induced by numerical viscosity.

M.S.K.

A85-40689\*# National Aeronautics and Space Administration,  
Ames Research Center, Moffett Field, Calif.

**A HOLOGRAPHIC INTERFEROMETRIC STUDY OF AN  
AXISYMMETRIC SHOCK-WAVE/BOUNDARY-LAYER STRONG  
INTERACTION FLOW**

S. E. DUNAGAN, J. L. BROWN (NASA, Ames Research Center,  
Moffett Field, CA), and J. B. MILES (Missouri, University,  
Columbia) American Institute of Aeronautics and Astronautics,  
Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th,  
Cincinnati, OH, July 16-18, 1985. 18 p. refs  
(AIAA PAPER 85-1564)

The results of a holographic interferometric and analytical examination of shock wave/turbulent boundary layer interactions occurring in a flow near a cone-cylinder intersection are reported. A Mach 2.85 flow with an Re of 18 million was used, along with cone angles of 12.5, 20 and 30 deg. Negligible, incipient and large scale separations were observed. The subsonic layer of the boundary always remained thin and was usually penetrated by the shock wave. An Abel transform, applied to the interferometric traces, yielded a great deal of data on the density field when combined with data from application of laser velocimeter, pressure tap and oil flow techniques.

M.S.K.

A85-40690#

**COMPUTATION OF A THREE DIMENSIONAL SKEWED SHOCK  
WAVE LAMINAR BOUNDARY LAYER INTERACTION**

G. DEGREGZ (Bruxelles, Universite Libre, Brussels; Institut von  
Karman de Dynamique des Fluides, Rhode-Saint-Genese,  
Belgium) American Institute of Aeronautics and Astronautics,  
Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th,  
Cincinnati, OH, July 16-18, 1985. 9 p. FNRS-supported research.  
refs

(Contract AF-AFOSR-82-0051)  
(AIAA PAPER 85-1565)

The implicit approximate factorization scheme of Beam and Warming (1978) has been coded to solve the compressible Navier-Stokes equations for the three dimensional interaction caused by a swept oblique shock wave normal to a laminar boundary layer. The shock generator compression angle was 6 deg and the Mach and Reynolds numbers were 2.25 and 108,000 respectively. Two meshes were used successively to study the influence of the mesh spacing. The numerical results reproduce the essential features of the flow field, namely the extended separation of the boundary layer and the conical nature of the interaction footprint. In addition, they clearly indicate the presence of an elongated vortical structure beneath the outer shock wave.

Author

A85-40691\*# Washington Univ., Seattle.

**AN EXPERIMENTAL STUDY OF THREE-DIMENSIONAL SHOCK  
WAVE/TURBULENT BOUNDARY LAYER INTERACTIONS IN A  
SUPERSONIC FLOW**

J. H. CHOU, M. E. CHILDS (Washington, University, Seattle), and  
R. S. WONG (TRW, Inc., Redondo Beach, CA) American Institute  
of Aeronautics and Astronautics, Fluid Dynamics and  
Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July  
16-18, 1985. 9 p. refs  
(Contract NAG3-256)  
(AIAA PAPER 85-1566)

Wall static pressure distributions, surface flow patterns, pitot pressures, and yaw angle profiles were measured in a skewed three-dimensional shock wave/turbulent boundary layer interaction region. The test section was axisymmetric with a constant diameter. The nominal freestream Mach number was 4. Upstream of the interaction, the boundary layer thickness was 0.31 in. (0.787 cm). The three-dimensional flow was produced by azimuthal pressure gradients which were generated by an 8-degree cone aligned with the primary flow direction, but with the cone axis displaced 0.3 in. (0.76 cm) from the channel centerline. The yaw angle was found to be a function of both the azimuthal angle and the distance from the beginning of the interaction. It was observed that yaw angle increased substantially near the wall. The maximum yaw angle for the whole flow field was obtained in the 90 degree azimuthal plane.

Author

A85-40692#

**SHOCK/TURBULENT BOUNDARY-LAYER INTERACTION IN A  
COMPRESSION CORNER**

J. E. DEESE and R. K. AGARWAL (McDonnell Douglas Research  
Laboratories, St. Louis, MO) American Institute of Aeronautics  
and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers  
Conference, 18th, Cincinnati, OH, July 16-18, 1985. 12 p. Research  
supported by the McDonnell Douglas Independent Research and  
Development Program. refs  
(AIAA PAPER 85-1567)

A numerical algorithm is presented for solving the unsteady compressible Navier-Stokes equations. The solution procedure is based on the Runge-Kutta time-stepping scheme of Jameson, Schmidt, and Turkel (1981). The Baldwin-Lomax algebraic eddy viscosity turbulence model is used. Flowfields over a compression corner at supersonic speeds are computed. Attached and separated flow predictions are compared with experimental data and the calculations of other investigators.

Author

## 02 AERODYNAMICS

**A85-40697\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### **INSTABILITIES AND TRANSITION IN THE WALL BOUNDARY LAYERS OF LOW-DISTURBANCE SUPERSONIC NOZZLES**

F.-J. CHEN, M. R. MALIK, and I. E. BECKWITH (NASA, Langley Research Center, Hampton, VA) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 15 p. refs (AIAA PAPER 85-1573)

Linear stability analysis and experimental nozzles were employed in studying means to control Tollmein-Schlichting (TS) waves and Taylor-Goertler (TG) vortices at transition points along walls in a supersonic wind tunnel. It was hoped that control of the TS waves and TG vortices would cause the wall flows to remain laminar, thereby reducing the turbulence noise in the tunnel. The test nozzles injecting the waves and vortices had Mach numbers from 3 to 5. TG vortices triggered transition, while axisymmetric nozzle flows suppressed it. TS waves were controllable with favorable pressure gradients at Mach 3.5. Finally, advances were made in the capability of predicting the locations of the transition points. M.S.K.

**A85-40703#**

### **THE ENTRAINMENT EFFECT OF A LEADING-EDGE VORTEX**

N. G. VERHAAGEN and A. C. H. KRUISBRINK (Delft, Technische Hogeschool, Netherlands) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 10 p. refs (AIAA PAPER 85-1584)

An investigation into the characteristics of the flow inside a leading-edge vortex is described. The objective of the investigation is to support the development of mathematical models for leading-edge vortex flow by measuring in detail the flow properties of the core of a leading-edge vortex, and by comparing these results with theory. The velocity distribution inside the core is well predicted by Stewartson and Hall's outer solution, and the resulting distributions of the entrainment and circulation correlate well with the measured distributions. The effect of the inclusion of the entrainment on the computed characteristics of a slender delta wing is demonstrated using a higher-order panel method. Author

**A85-40705\*#** Maryland Univ., College Park.

### **LIFT DUE TO THICKNESS FOR LOW ASPECT RATIO WINGS IN INCOMPRESSIBLE FLOW**

S. S. DODBELE and A. PLOTKIN (Maryland, University, College Park) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 13 p. refs (Contract NCC1-41) (AIAA PAPER 85-1588)

The problem under consideration is a numerical study of the effects of thickness on lift for low aspect ratio wings in steady incompressible inviscid flow at moderate angles of attack. At these angles of attack the flow separates along the leading edge giving rise to a lift substantially higher than that computed by classical attached flow potential theory. The problem is treated as a perturbation expansion in a small thickness parameter. The lifting elements of the flow are modeled using a nonlinear vortex lattice method which replaces the leading and trailing edge vortex sheets by segmented straight vortex filaments. The thickness elements of the flow are modeled with a mean plane source distribution and a modification to the wing boundary conditions. Results are obtained for wings with biconvex and NACA 0012 sections which compare well with available experimental data. The important observation that the effect of thickness is to decrease the lift is made. Author

**A85-40706#**

### **THE SPANWISE VARIATION OF LAMINAR SEPARATION BUBBLES ON FINITE WINGS AT LOW REYNOLDS NUMBERS**

W. G. BASTEDO, JR. and T. J. MUELLER (Notre Dame, University, IN) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 13 p. refs (Contract N00014-83-K-0239) (AIAA PAPER 85-1590)

The Wortmann FX 63-137 airfoil section and three rectangular wings were studied for chord Reynolds numbers ranging from 80,000 to 200,000. It was found that increasing chord Reynolds number increased performance of both the airfoil and the wings, while decreasing wing aspect ratio adversely affected performance. Behavior of the laminar separation bubble that formed was studied for both the airfoil and one wing. Determination of tip vortex interaction with the separation bubble was attempted. Chordwise static pressure distributions were obtained along the span and were used with flow visualization data to document the location of the laminar separation bubble. The flow visualization data showed the tip vortex reduced the local angle of attack along the span. Comparison of two-dimensional pressure distributions to those along the span showed little difference between the bubble that formed locally and its 2-D counterpart at the equivalent effective angle of attack. Author

**A85-40707#**

### **AN INVESTIGATION OF FILM COOLING ON A HYPERSONIC VEHICLE USING A PNS FLOW ANALYSIS CODE**

G. J. BANKEN, D. W. ROBERTS (Amtec Engineering, Inc., Bellevue, WA), J. E. HOLCOMB, and S. F. BIRCH (Boeing Aerospace Co., Seattle, WA) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 13 p. refs (AIAA PAPER 85-1591)

An analysis has been developed for calculating the three-dimensional flow field associated with slot cooling at hypersonic speeds. The work involves modifications to an existing PNS code to accommodate the more complex geometry encountered in slot cooling applications and to extend the range of application of the code to hypersonic speeds. The major modification of the code required for the hypersonic calculations was the incorporation of a real gas model. It is demonstrated that this can be accomplished for a cost penalty, over the equivalent ideal gas calculation, of only 5 to 10 percent. The resulting code was used to conduct a parametric study of slot cooling efficiency, including an angle-of-attack calculation. The influence of Mach number on the turbulent mixing rate of the slot flow is also discussed. Author

**A85-40708#**

### **TRANSONIC AIRFOIL DESIGN BASED ON NAVIER-STOKES EQUATION TO ATTAIN ARBITRARILY SPECIFIED PRESSURE DISTRIBUTION - AN ITERATIVE PROCEDURE**

N. HIROSE, S. TAKANASHI, and N. KAWAI (National Aerospace Laboratory, Tokyo, Japan) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 10 p. refs (AIAA PAPER 85-1592)

An iterative procedure of transonic airfoil design based on Navier-Stokes equation to attain arbitrarily specified pressure distribution is proposed. Transonic integral equation for the inverse problem for the correction term between the basic pressure distribution and the specified pressure distribution is formulated and is combined with a time-averaged Navier-Stokes analysis code, NSFOIL, for high Reynolds number transonic flow past an airfoil, which uses Beam-Warming-Steger Implicit Approximate Factorization scheme with an improved implicit boundary point treatment. Shock wave and viscous effects including weak separation are properly evaluated in the analysis mode and therefore are effectively incorporated in the design procedure. Numerical results for shockless pressure distribution and supercritical pressure distribution are presented. A small number

of iterative steps yields practically satisfied airfoil geometry. The method can be more easily applicable to low speed airfoil design. Both of conventional and unconventional pressure distributions are designed and presented. Author

**A85-40709\*# Arizona Univ., Tucson.  
REFINED NUMERICAL SOLUTION OF THE TRANSONIC FLOW  
PAST A WEDGE**

S.-M. LIANG and K.-Y. FUNG (Arizona, University, Tucson) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 6 p. refs  
(Contract AF-AFOSR-83-0071; NGT-03-002-800)  
(AIAA PAPER 85-1593)

A numerical procedure combining the ideas of solving a modified difference equation and of adaptive mesh refinement is introduced. The numerical solution on a fixed grid is improved by using better approximations of the truncation error computed from local subdomain grid refinements. This technique is used to obtain refined solutions of steady, inviscid, transonic flow past a wedge. The effects of truncation error on the pressure distribution, wave drag, sonic line, and shock position are investigated. By comparing the pressure drag on the wedge and wave drag due to the shocks, a supersonic-to-supersonic shock originating from the wedge shoulder is confirmed. Author

**A85-40710#  
NEW ITERATIVE ALGORITHM BETWEEN STREAM FUNCTION  
AND DENSITY FOR TRANSONIC CASCADE FLOW**

B.-G. WANG (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of China) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 9 p. refs  
(AIAA PAPER 85-1594)

A set of Wu's equations (1952, 1963, 1975, 1976, 1984) governing the fluid flow along a given S1 stream surface is solved by the use of artificial compressibility and with a new iterative algorithm between the two variables, stream function and density. The set of equations consists of a stream-function equation and a new first-order partial differential equation for density derived from the continuity equation, momentum equation, and Bernoulli's equation. The stream-function equation proposed by Wu more than 30 years ago is written in general curvilinear coordinate system to allow for arbitrary boundary shapes. A strongly implicit approximate factorization algorithm (SI) of multidimensional partial differential equations is used in numerical solutions of this set of equations. By this, the problem of nonuniqueness of density in a traditional stream-function method is avoided. A number of transonic cascades are calculated and given herein to demonstrate the capability of the present method. Author

**A85-40711#  
COMPUTATION OF THREE-DIMENSIONAL TRANSONIC  
VISCOUS FLOWFIELDS USING UNSTEADY PARABOLIZED  
NAVIER-STOKES EQUATIONS**

R. K. AGARWAL, J. E. DEESE (McDonnell Douglas Corp., St. Louis, MO), and R. R. UNDERWOOD American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 6 p. Research supported by the McDonnell Douglas Independent Research and Development Program. refs  
(AIAA PAPER 85-1595)

Unsteady parabolized Navier-Stokes (slender-shear-layer) equations are derived in a curvilinear coordinate system by neglecting the diffusion terms in the streamwise direction. These equations are suitable for calculating flow along a wing-body junction and spanwise separation; they are solved by a finite-volume, Runge-Kutta time-stepping scheme. Calculations are presented for flow over a wing. Author

**A85-40712#  
TRANSONIC FLOW CALCULATIONS AROUND ISOLATED  
INLET CONFIGURATIONS**

A. J. PEACE (Aircraft Research Association, Ltd., Bedford, England) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 7 p. Research supported by the Ministry of Defence. refs  
(AIAA PAPER 85-1596)

A numerical method for calculating transonic flow around general inlet configurations is presented. The method is based on a finite volume potential flow algorithm with enhancements to reduce truncation errors. An approximate factorization iterative scheme is employed and the computer code is written to take advantage of a vector machine's architecture. The method has also been coupled with an integral boundary layer method to take into account viscous effects on the inlet surface. Results are obtained on a number of geometries which are representative of current design trends, at both take-off and cruise conditions. Comparison with experimental data shows favorable agreement. The method is shown to be accurate, reliable and cheap to run. Author

**A85-40713#  
A NAVIER-STOKES SOLUTION PROCEDURE FOR ANALYSIS  
OF STEADY TWO-DIMENSIONAL TRANSONIC NOZZLE  
FLOWS**

O. K. KWON and R. A. DELANEY (General Motors Corp., Indianapolis, IN) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 9 p. refs  
(AIAA PAPER 85-1597)

An efficient Navier-Stokes solver is presented to analyze steady planar and axisymmetric transonic nozzle flows. The method solves the time-dependent compressible Navier-Stokes equations in conservation form in generalized body-fitted coordinates using an efficient hopscotch numerical algorithm. Various steady transonic laminar viscous nozzle flows are analyzed. Computed results are presented and compared with experimental data to demonstrate the accuracy and computational efficiency of the numerical method. Author

**A85-40719#  
SUPERSONIC AERODYNAMIC CHARACTERISTICS OF  
ELLIPTIC CROSS SECTION BODIES**

P. F. AMIDON (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 12 p. refs  
(AIAA PAPER 85-1607)

A supersonic wind-tunnel test was performed on a parametric set of advanced missile bodies with elliptical cross section. Models with ellipticity ratios of 2.0:1, 2.5:1, and 3.0:1 were tested at Mach numbers from 1.5 to 5.0 and up to 20 degrees angle of attack. Both pressure and force and moment data were obtained, as well as schlieren, oil flow, and laser vapor screen flow visualization data. The purpose of the test was to obtain detailed data for comparison with selected analytical methods. Results indicate the Supersonic/Hypersonic Arbitrary Body Program (Gentry et al., 1973) inadequately predicts leading-edge ann leeside surface pressures, especially at lower Mach numbers. The good agreement of the Naval Surface Weapons Center inviscid Euler code (Wardlaw et al., 1981) with test data indicates the potential for these types of codes in predicting elliptical body aerodynamics. Author

## 02 AERODYNAMICS

**A85-40720\*#** McDonnell-Douglas Corp., St. Louis, Mo.  
**THE BUFFETING PRESSURE FIELD OF A HIGH-ASPECT-RATIO SWEEP WING**

F. W. ROOS (McDonnell Douglas Research Laboratories, St. Louis, MO) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 8 p. Research supported by the McDonnell Douglas Independent Research and Development Program and NASA. refs  
(AIAA PAPER 85-1609)

An experimental study of the fluctuating pressure field of a high-aspect-ratio swept transport-type wing model in transonic buffeting flow is examined. A high degree of similarity between the buffet-related features of the wing flowfield and 2-D transonic flowfields is indicated. At several spanwise stations, unsteady lift produced by the pressure fluctuations is evaluated and found to increase in intensity as local flow separation develops. Results show that although the wing does vibrate, the measured lift fluctuations are driving, and not driven by wing vibrations. The influence of tunnel-flow unsteadiness on the data is considered.

M.D.

**A85-40724#**  
**RECENT DEVELOPMENTS IN THE MODELING OF HIGH SPEED JETS, PLUMES AND WAKES**

S. M. DASH (Science Applications International Corp., Propulsion Gas Dynamics Div., Princeton, NJ) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 36 p. refs  
(AIAA PAPER 85-1616)

A review of recent developments in the ability to simulate the flow structure, thermo-chemistry, and turbulence in high speed jets, aircraft and rocket plumes and hypersonic wakes is presented. The review is limited to axisymmetric problems for which 'practical' computational models are now operational or in a reasonable state of development. The discussion includes computational aspects of the modeling, as well as turbulence modeling features and procedures for dealing with thermo-chemical and multi-phase problems.

Author

**A85-40725#**  
**COMPARISON OF EXPERIMENT AND COMPUTATION FOR A MISSILE BASE REGION FLOWFIELD WITH A CENTERED PROPULSIVE JET**

H. L. PETRIE and B. J. WALKER (U.S. Army, Missile Laboratory, Redstone Arsenal, AL) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 12 p. refs  
(AIAA PAPER 85-1618)

Two propulsive nozzle exit-to-freestream static pressure ratios were calculated in the present comparative study of the results thus obtained with experimental data for an axisymmetric tangent-ogive missile afterbody and centered propulsive jet in a Mach 1.4 freestream flow. Comparison results are used to evaluate current prediction capabilities for complex separated supersonic flows. The computational approaches employed encompass thin layer Navier-Stokes codes with an algebraic turbulent eddy viscosity model, full Navier-Stokes codes with two-equation turbulence models, and component model predictions of the base pressure. Thin layer Navier-Stokes calculations were undertaken with both fixed and adaptive grids.

O.C.

**A85-40727#**  
**BASE PRESSURE CONTROL BY PASSIVE METHODS**

G. IUSO (Torino, Politecnico, Turin, Italy) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 10 p. Research supported by the Ministero della Pubblica Istruzione. refs  
(AIAA PAPER 85-1620)

The study of the flow around an axisymmetric cylinder, aligned with the flow, having an ogival nose and a slanted base, is

discussed. Details of the flow behavior are measured in order to explain the body drag as a function of the base slant angle. The control of the base pressure distribution and the body drag by different passive methods is considered. It is shown that drag reductions from 20 to 60 percent are achieved, depending on the base slant angle. By observing the behavior of the wake flow, the results are analyzed.

M.D.

**A85-40728\*#** Washington Univ., Seattle.  
**EXPERIMENTAL AND NUMERICAL INVESTIGATION OF SUPERSONIC FLOW THROUGH A SQUARE DUCT**

D. O. DAVIS, F. B. GESSNER (Washington, University, Seattle), and G. D. KERLICK (Informatics General Corp., Moffett Field, CA) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 13 p. refs  
(Contract NCA2-IR-850-401)  
(AIAA PAPER 85-1622)

Steady, developing, adiabatic supersonic flow in a square duct is investigated for an inlet Mach number of 3.91 and a unit Reynolds number of  $1.8 \times 10$  to the 6th/m. The numerical results for laminar flow show that two secondary flow cells develop in the near vicinity of the corner which are centered about the corner bisector and distort the primary flow in this region. For turbulent flow, the experimental results indicate that two secondary flow cells also develop about the corner bisector, but are directed in an opposite sense to that observed for the laminar case. Numerical results based on the Baldwin-Lomax model show that this model is incapable of predicting turbulence-generated secondary flow cells. For a suitable choice of constants, the Gessner-Emery model is able to predict the strength of these cells, but is deficient with respect to predicting their positions in the flow and their distorting influence on the primary flow. These observations are based on comparisons made in this paper between predicted and measured total pressure contours, cross flow velocity profiles, and local wall shear stress distributions.

Author

**A85-40729\*#** National Aeronautics and Space Administration.  
Langley Research Center, Hampton, Va.  
**BOUNDARY LAYER EFFECTS ON THE FLOWFIELD ABOUT FLOW-THROUGH NACELLES**

W. B. COMPTON (NASA, Langley Research Center, Hampton, VA) and J. L. WHITESIDES (Joint Institute for Advancement of Flight Sciences, Hampton, VA) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 13 p. refs  
(AIAA PAPER 85-1623)

A numerical study has been made of boundary layer effects on the flowfield about flow-through nacelles. A viscous-inviscid interacting computational model for investigating the problem was constructed by coupling a three-dimensional explicit Euler solution procedure with a compressible, 'lag-entrainment' integral boundary layer solution technique. Solutions obtained with the interacting model for long-duct turbofan engine nacelles at a free stream Mach number of 0.8 and an angle of attack of 0 deg are compared with experimental data. The numerical experiments have revealed insight into the boundary layer effects on the interactions between the internal and external flows.

Author

**A85-40732\*#**  
**ADAPTIVE MESH SOLUTION FOR SUPERSONIC CONICAL FLOW IN A RECTILINEAR INLET**

G. D. KERLICK (Informatics General Corp., Moffett Field, CA) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 12 p. refs  
(Contract NAS2-11555)  
(AIAA PAPER 85-1626)

Solutions for the inviscid and viscous supersonic conical flow in a complete rectilinear inlet consisting of four planes intersecting at arbitrary wedge and sweep angles are obtained. To compute the flow on a specially constructed mesh, a three-dimensional flow solver ARC3D is used. It is shown that a single-pass mesh



re-adaptation procedure can be used to obtain improved shock capture without the necessity of modifying the flow code, provided that the flow solver works in curvilinear coordinates and is restartable. Results computed by the method show good agreement with experimental measurements and previous calculations. M.D.

**A85-40741#**

**TRANSONIC TURBULENT FLOW COMPUTATIONS FOR AXISYMMETRIC AFTERBODIES**

U. C. GOLDBERG, J. J. GORSKI, and S. R. CHAKRAVARTHY (Rockwell International Science Center, Thousand Oaks, CA) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 9 p. refs  
(AIAA PAPER 85-1639)

The flow field around nozzle-afterbody configurations is computed using a new finite volume code, incorporating a Total Variation Diminishing implicit upward biased scheme for high accuracy. Computations are done for both solid plume simulators and actual jet exhaust flows. Results are shown for several combinations of jets and free-stream flow parameters and for two geometries, using k-epsilon and Baldwin-Lomax turbulence models, alternatively. Agreement with experimental data is very good.

Author

**A85-40742\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**NUMERICAL SOLUTION OF TRANSONIC WING FLOWS USING AN EULER/NAVIER-STOKES ZONAL APPROACH**

T. L. HOLST, K. L. GUNDY, S. D. THOMAS, N. M. CHADERJIAN (NASA, Ames Research Center, Moffett Field, CA), J. FLORES (Informatics General Corp., Palo Alto, CA) et al. American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 14 p. refs  
(Contract NCA2-OR-745-309)  
(AIAA PAPER 85-1640)

Transonic flow fields about wing geometries are computed using an Euler/Navier-Stokes approach in which the flow field is divided into several zones. The grid zones immediately adjacent to the wing surface are suitably clustered and solved with the Navier-Stokes equations. Grid zones removed from the wing are less finely clustered and are solved with the Euler equations. Wind tunnel wall effects are easily and accurately modeled with the new grid-zoning algorithm because the wind tunnel grid is constructed as an exact subset of the corresponding free-air grid. Solutions are obtained that are in good agreement with experiment, including cases with significant wind tunnel wall effects and shock-induced separation on the upper wing surface.

Author

**A85-40743#**

**IMPROVEMENTS IN TRANSONIC AIRFOIL POTENTIAL FLOW CALCULATIONS**

L. T. CHEN, R. W. CLARK, and J. C. VASSBERG (Douglas Aircraft Co., Long Beach, CA) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 8 p. Research sponsored by the McDonnell Douglas Independent Research and Development Program. refs  
(AIAA PAPER 85-1642)

Several useful improvements of the transonic potential airfoil flowfield computational method will be presented. A method is developed which allows the entropy correction downstream of shocks, and also enforces the Kutta condition according to the difference of total pressures at upper and lower trailing edges. Calculations show that this nonisentropic Kutta condition has a significant effect on the shock calculations and yields solutions agreeing better with Euler solutions. For the benefit of aerodynamic design, a new procedure to compute wave drag and a procedure to treat lift as an input parameter in a C-mesh airfoil code will be described.

Author

**A85-40744\*#** Arizona Univ., Tucson.

**COMPUTATION OF UNSTEADY TRANSONIC AERODYNAMICS WITH STEADY STATE FIXED BY TRUNCATION ERROR INJECTION**

K.-Y. FUNG and J.-K. FU (Arizona, University, Tucson) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 5 p. refs  
(Contract AF-AFOSR-83-0071; NGT-03-002-800)  
(AIAA PAPER 85-1644)

A novel technique is introduced for efficient computations of unsteady transonic aerodynamics. The steady flow corresponding to body shape is maintained by truncation error injection while the perturbed unsteady flows corresponding to unsteady body motions are being computed. This allows the use of different grids comparable to the characteristic length scales of the steady and unsteady flows and, hence, allows efficient computation of the unsteady perturbations. An example of typical unsteady computation of flow over a supercritical airfoil shows that substantial savings in computation time and storage without loss of solution accuracy can easily be achieved. This technique is easy to apply and requires very few changes to existing codes.

Author

**A85-40754\*#** Washington Univ., Seattle.

**MEASUREMENTS OF TURBULENT CORRELATIONS IN SUPERSONIC FLOWS WITH LONGITUDINAL SURFACE CURVATURE**

J. H. CHOU (Washington, University, Seattle) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 8 p. refs  
(Contract NGR-48-002-047; NGR-48-002-141)  
(AIAA PAPER 85-1656)

The effect of longitudinal surface curvature on the turbulent correlations of a supersonic turbulent boundary layer was studied experimentally in an axisymmetric channel. Upstream of the interaction, the nominal freestream Mach number was 3.78, the Reynolds number based on boundary layer momentum thickness was 5778, and the boundary layer thickness was 0.9 cm. For the flow with the longitudinal surface curvature, the overall turning angle was approximately 10.2 degrees, and maximum  $\delta\alpha/\kappa$  approximately 0.09. The shear stresses, measured by a hot wire anemometry, reached the peak values quite rapidly for the flow with surface curvature as compared to the corresponding flow without surface curvature.

Author

**A85-40756\*#** Tokyo Univ. (Japan).

**COMPUTATION OF FLOW AROUND A CIRCULAR CYLINDER IN A SUPERCRITICAL REGIME**

K. ISHII, K. KUWAHARA, T. KAWAMURA (Tokyo, University, Japan), S. OGAWA (National Aerospace Laboratory, Tokyo, Japan), and W. J. CHYU (NASA, Ames Research Center, Moffett Field, CA) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 13 p. refs  
(AIAA PAPER 85-1660)

Compressible flows around a circular cylinder in a supercritical regime at Mach number 0.3 have been calculated by using the Beam-Warming-Steger scheme based on the full Navier-Stokes equations with improved accuracy. The flow patterns are visualized extensively to observe the characteristics in this regime. The computations show that the flow at certain Reynolds numbers in a supercritical regime becomes rather steady and irregular with small drag coefficients. This may correspond to the experimental observations that the Strouhal number can not be measured clearly at a certain Reynolds number range in the supercritical regime.

Author

## 02 AERODYNAMICS

**A85-40760\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### **NUMERICAL SIMULATION OF FLOW THROUGH SCRAMJET INLETS USING A THREE-DIMENSIONAL NAVIER-STOKES CODE**

A. KUMAR (NASA, Langley Research Center, Hampton, VA) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 9 p. refs

(AIAA PAPER 85-1664)

A three-dimensional Reynolds-averaged Navier-Stokes code has been used to numerically analyze flow through a two-strut, supersonic combustion ramjet (scramjet) inlet configuration. It solves the governing equations in full conservation form using either the fully explicit or explicit-implicit method due to MacCormack. An algebraic two-layer eddy viscosity model is used for turbulent flow calculations. The analysis allows inclusion of end effects which are caused by the aft placement of the cowl on the underside of the inlet. A special grid has been developed to accommodate the struts embedded in the inlet flow field. Detailed numerical results are presented here for the two-strut configuration, and a comparison is made with the available experimental results.

Author

**A85-40762#**

### **OVERLAID APPROACH FOR BASE FLOW ANALYSIS AT SUPERSONIC VELOCITIES. I - BASIC MODEL DESCRIPTION. II - APPLICATIONS INCLUDING BASE COMBUSTION AND MULTI-PHASE EXHAUST EFFECTS**

N. SINHA and S. M. DASH (Science Applications International Corp., Propulsion Gas Dynamics Div., Princeton, NJ) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 19 p. refs

(Contract DAAH01-82-C-0514)

(AIAA PAPER 85-1673)

A new zonal approach for analyzing the base region of missiles at supersonic flight velocities is presented. Sophisticated finite difference components are utilized within the overall framework of Korst patched component methodology. The inviscid base region flow structure is analyzed by a variant of the shock-capturing model, (SCIPPY). The curved shear layers growing along the base region slipstreams are analyzed by a variant of the turbulent mixing model, (SPLITP). Both SCIPPY and SPLITP utilized specialized mappings to resolve the details of strong gradient regions. SPLITP implements an overlaid approach to interface with the inviscid SCIPPY solution and can account for both streamwise and normal variations in the pressure field and edge boundary conditions. The external flow boundary layer is treated in a detailed fashion in both the inviscid and viscous solutions. A modification of the heuristic formulation of Addy (1969) is employed to analyze the recompression region. Part I of this paper describes the basic model formulation. In Part II, extensions to realistic missile problems with base combustion and multi-phase exhausts are described.

Author

**A85-40763\*#** Virginia Polytechnic Inst. and State Univ., Blacksburg.

### **EFFECTS OF NON-UNIFORM VELOCITY PROFILES ON DUAL JETS IN A CROSSFLOW**

C. L. MOORE and J. A. SCHETZ (Virginia Polytechnic Institute and State University, Blacksburg) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 10 p. NASA-supported research. refs

(AIAA PAPER 85-1674)

The interaction between engine exhaust jets and the freestream affects the aerodynamic and stability characteristics of VTOL aircraft during the transition from hover to forward flight. This interaction is often modeled as a simple uniform jet issuing from a flat plate into a subsonic crossflow. The distribution of pressures induced by the jet on the surface of the plate can be used to predict the lift loss and pitching moment for a full-scale aircraft. The uniform jet model has limitations because an actual turbofan

engine generates a rather nonuniform exit velocity profile. The purpose of this work is to study the effect of a nonuniform velocity profile on the surface pressure distribution. The mutual interaction of dual jets also is investigated in side-by-side and tandem configurations. Detailed pressure distributions are presented for two jet-to-freestream velocity ratios of 2.2 and 4.0. One important finding is that a nonuniform jet with a high velocity periphery and a low velocity core has a higher effective velocity ratio than a uniform jet with the same mass flow.

Author

**A85-40764#**

### **VELOCITY CHARACTERISTICS OF THE WAKES OF IN-CYLINDER PROJECTILES**

A. F. BICEN, Y. KLIAFAS, and J. H. WHITELAW (Imperial College of Science and Technology, London, England) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 7 p.

(Contract DAJA45-84-C-0032)

(AIAA PAPER 85-1676)

Time-resolved velocity and pressure have been measured in the wake of in-cylinder projectiles accelerated from rest by compressed gas in a 76.7 mm diameter cylinder with initial chambers of 177.3 and 311 mm length. The initial gas pressures ranged from 1.96 to 9.1 bars with a maximum projectile velocity of around 21 m/s over a 300 mm travel. The results show that the flow is nearly one-dimensional with boundary layers of the order of 1 percent of the cylinder diameter and maximum turbulence intensities in the bulk flow of around 3 percent. In general, the flow velocity characteristics scale with projectile velocity.

Author

**A85-40765#**

### **FLOW SIMULATIONS USING EULER EQUATIONS FOR NACELLE-PROPELLER CONFIGURATIONS IN A WIND TUNNEL ENVIRONMENT**

H. C. CHEN and S. S. SAMANT (Boeing Commercial Airplane Co., Seattle, WA) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 7 p. Research supported by the Boeing Independent Research and Development Program. refs

(AIAA PAPER 85-1678)

A simulation method has been developed to analyze nacelle-propeller configurations in a wind tunnel environment. Euler equations have been used to model the wind tunnel nacelle-propeller flow field including propeller power effects and the effects of a transverse suction slot in the wind tunnel wall. The flow field is discretized by a surface-fitted grid calculated using an algebraic approach. The suction slot on the tunnel wall is simulated by prescribing a normal mass flux distribution. A given tunnel entrance Mach number is achieved by adjusting the tunnel exit flow condition, for example by adjusting the exit static pressure. The analysis results correlated well with test data and the present Euler code has been used to give important guidelines for the wind tunnel experiment setup to study the propfan aerodynamics.

Author

**A85-40767#**

### **INVISCID FLOW FIELD ANALYSIS OF MANEUVERING HYPERSONIC VEHICLES USING THE SCM FORMULATION AND PARABOLIC GRID GENERATION**

R. W. NOACK (Sandia National Laboratory, Albuquerque, NM) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 13 p. refs

(Contract DE-AC04-76DP-00789)

(AIAA PAPER 85-1682)

The split-coefficient matrix (SCM) form of the Euler equations for a cylindrical base coordinate system is extended to allow the use of a generalized three-dimensional grid generation scheme. A grid generation scheme based on a parabolic partial differential equation is developed. Grids are obtained without iteration by marching from the body to the shock with body and shock points

specified. The SCM type body boundary condition has been found to underpredict surface pressure for geometries with small radii of curvature. An improved method of characteristic (MOC) type body boundary condition has been developed which uses SCM type differencing in the crossflow direction. The improved MOC boundary condition has been found to have the robustness of the SCM type scheme while having superior accuracy. Solutions using the SCM form of the Euler equations with the parabolic grid generator and the improved MOC body boundary condition have been obtained for a hypersonic six fin missile. Generally good agreement is found in comparisons of the inviscid predictions with experimental data. Author

**A85-40768\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.  
**PREDICTIONS OF TRANSONIC SEPARATED FLOW WITH AN EDDY-VISCOSITY/REYNOLDS-SHEAR-STRESS CLOSURE MODEL**

D. A. JOHNSON (NASA, Ames Research Center, Moffett Field, CA) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 18 p. refs (AIAA PAPER 85-1683)

In previous work, a new turbulence-closure model was specifically developed for two-dimensional turbulent boundary layers subjected to strong, adverse-pressure gradients and the attendant separation. This closure model was shown to perform well, but the inverse, boundary-layer calculations used in evaluating the model were not truly predictive since the mass-flux parameter distribution obtained from the experimental data had to be specified. The objective of this study was to evaluate this closure model for a series of strong, transonic, inviscid-viscous interactions with varying degrees of separation using a fully predictive calculation method based on the Reynolds-averaged, Navier-Stokes equations. Calculated results are compared with experimental results and are shown to be in excellent agreement, even for the interactions with massive separation. This closure model has the very favorable property of requiring little more computational effort than equilibrium, algebraic models. Author

**A85-40769\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.  
**TIME-DEPENDENT NAVIER-STOKES COMPUTATIONS OF SEPARATED FLOWS OVER AIRFOILS**

C. L. RUMSEY (NASA, Langley Research Center, Hampton, VA) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 13 p. refs (AIAA PAPER 85-1684)

The application of both a central-difference and an upwind implicit approximate factorization Navier-Stokes algorithm to highly separated flow is described. Using the thin-layer approximation, both algorithms are employed to solve the low Reynolds number laminar flow around a circular cylinder with periodic shedding. Results agree with experimental Strouhal numbers to within about 10 percent. A grid refinement study is conducted using the upwind code for both the thin-layer and complete Navier-Stokes approximations. The circular cylinder solution is shown to be highly dependent upon both grid density outward from the body and grid extent. Finally, the thin-layer central-difference code is used to predict the time-accurate unsteady flow about two stalled airfoils. The NACA 0012 airfoil turbulent solutions are periodic with Strouhal numbers of about 0.1; a strong vortex is periodically shed from the leading edge. The LS(1)-0417 airfoil turbulent solution shows a high frequency oscillatory trailing edge separation. The 20 degree NACA 0012 airfoil solution is massively separated, but shows no evidence of periodicity. Author

**A85-40770\*#** United Technologies Research Center, East Hartford, Conn.

**ANALYSIS OF TRANSITIONAL SEPARATION BUBBLES ON INFINITE SWEEP WINGS**

R. L. DAVIS, J. E. CARTER (United Technologies Research Center, East Hartford, CT), and E. RESHOTKO (Case Western Reserve University, Cleveland, OH) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 11 p. refs (Contract NAS1-16585) (AIAA PAPER 85-1685)

A previously developed two-dimensional local inviscid-viscous interaction technique for the analysis of airfoil transitional separation bubbles, ALESEP (Airfoil Leading Edge Separation), has been extended for the calculation of transitional separation bubbles over infinite swept wings. As part of this effort, Roberts' empirical correlation, which is interpreted as a separated flow empirical extension of Mack's stability theory for attached flows, has been incorporated into the ALESEP procedure for the prediction of the transition location within the separation bubble. A series of two-dimensional calculations are presented as a verification of the prediction capability of the interaction technique with this transition model. Numerical tests have shown that this two-dimensional natural transition correlation may also be applied to transitional separation bubbles over infinite swept wings. Results of the interaction procedure are compared with Horton's detailed experimental data for separated flow over a swept plate which demonstrates the accuracy of the present technique. The principal conclusion of this paper is that the prediction of transitional separation bubbles over two-dimensional or infinite swept geometries is now possible using the present interacting boundary layer approach. Author

**A85-40772\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**ON THE ACCURACY OF THE PSEUDOCOMPRESSIBILITY METHOD IN SOLVING THE INCOMPRESSIBLE NAVIER-STOKES EQUATIONS**

S. E. ROGERS (NASA, Ames Research Center, Moffett Field, CA; Colorado, University, Boulder), D. KWAK (NASA, Ames Research Center, Moffett Field, CA), and U. KAUL (NASA, Ames Research Center, Moffett Field; Informatics General Corp., Palo Alto, CA) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 12 p. refs (Contract NCA2-OR-170-302) (AIAA PAPER 85-1689)

The method of pseudocompressibility is being tested for its accuracy in solving the incompressible Navier-Stokes equations. An implicit, finite-difference computer code is used to solve the equations in a three-dimensional, curvilinear coordinate system. The code employs artificial compressibility for solving the pressure field, coupled with an implicit, approximate-factorization scheme. This coupling is known as the pseudocompressibility method. The pseudocompressibility method introduces pressure waves of finite speed into the fluid medium that would otherwise have an infinite sound speed. The waves die out as the solution converges, and the steady state solution approaches a divergence-free condition. However, these waves limit the time-accuracy of the computations. The effects of these waves are analyzed and criteria are set for choosing the pseudocompressibility parameters that govern the pressure wave speed. Test cases are presented that verify these criteria. The code is tested by computing laminar flow over a two-dimensional, backward-facing step and over a two-dimensional, impulsively started circular cylinder. Author

## 02 AERODYNAMICS

**A85-40774#**

### COMPUTATIONAL STUDY OF UNSTEADY COMPRESSIBLE FLOW AROUND AN AIRFOIL BY A BLOCK PENTADIAGONAL MATRIX SCHEME

Y. SHIDA and K. KUWAHARA (Tokyo, University, Japan) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 11 p. refs -  
(AIAA PAPER 85-1692)

A time accurate method is introduced for solving the Navier-Stokes equations at high Reynolds number and applied for two unsteady cases. It is based on the approximate factorization method using an inversion of a block pentadiagonal matrix. In a one dimensional shock tube problem, the present method gave better results than those by Beam-Warming method and it proved to be more efficient. In a case of flows around an airfoil, after an improvement for the coefficient of the artificial dissipation, very fine structures of the flow are resolved. Especially, a strong leading edge suction maintained by turbulence-like small bubbles are observed in a case of high angle of attack. Author

**A85-40775#**

### SIMULATION OF WING, FUSELAGE, AND WING/FUSELAGE FLOWFIELDS USING A THREE-DIMENSIONAL EULER/NAVIER-STOKES ALGORITHM

J. VADYAK (Lockheed-Georgia Co., Marietta, GA) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 16 p. Research supported by the Lockheed Independent Research and Development Program. refs  
(AIAA PAPER 85-1693)

An analysis is presented for calculating steady (or unsteady) three-dimensional aircraft component flowfields. This algorithm can compute the flowfield about wing, fuselage, and wing/fuselage configurations operating at zero or nonzero incidence at subsonic, transonic, or supersonic free-stream speeds. The algorithm can solve the Euler momentum equations for inviscid flow, the thin-shear-layer Navier-Stokes equations for viscous flow, or the full Navier-Stokes equations for viscous flow. The flowfield is determined on a body-fitted numerically-generated computational grid. A fully-implicit alternating-direction-implicit algorithm is employed for solution of the finite-difference equations. Numerical results and correlations with both existing methods and experiment are presented to illustrate application of the analysis for steady flow cases at subsonic and transonic free-stream speeds. Author

**A85-40777\*#** Massachusetts Inst. of Tech., Cambridge.

### TOTAL PRESSURE LOSS IN VORTICAL SOLUTIONS OF THE CONICAL EULER EQUATIONS

K. G. POWELL, E. M. MURMAN, E. S. PEREZ, and J. R. BARON (MIT, Cambridge, MA) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 10 p. refs  
(Contract NAG1-358)  
(AIAA PAPER 85-1701)

A technique for the solution of the conically self-similar form of the Euler equations is described. Solutions for the flow past a flat-plate delta wing at angle of attack are presented. These solutions show strong leading edge vortices with large total pressure losses in the cores. A study of the effects of various computational parameters on the total pressure loss is made. An explanation for the cause of the total pressure loss is presented. It is shown to be consistent with the results for both a quasi-one-dimensional model problem and the conically self-similar flow past the flat-plate delta wing. Author

**A85-40779#**

### 2-D AND 3-D EULER FLOW CALCULATIONS WITH A SECOND-ORDER ACCURATE GALERKIN FINITE ELEMENT METHOD

F. ANGRAND, A. DERVIEUX (Institut National de Recherche en Informatique et en Automatique, Valbonne, France), V. BILLEY, J. PERIAUX, C. POULETTY (Avions Marcel-Dassault, Breguet Aviation, Saint-Cloud, France) et al. American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 9 p. refs  
(Contract DRET-84-014)  
(AIAA PAPER 85-1706)

A new 3-D Euler code is introduced and compared with its 2-D counterpart. The spatial approximation is a Galerkin FEM which applies to non-structured meshes; boundary conditions are constructed variationally. The temporal scheme is a two-step Richtmyer approximation. The resulting code proves its ability to compute internal/external shocked 3-D flows around and inside inlets. These simulations are performed on locally refined nonstructured tetrahedrizations generated by self adaptive algorithms. Author

**A85-40780#**

### UNSTEADY CHARACTERISTICS OF AN AIRFOIL INTERACTING WITH A VORTICAL WAKE

D. FAVIER, C. MARESCA (Aix-Marseille II, Universite, Marseille, France), and A. CASTEX American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 10 p. Sponsorship: Service Technique des Programmes Aeronautiques. refs  
(Contract STPA-83,95,004)  
(AIAA PAPER 85-1707)

The study is undertaken within the scope of simulating the effects of the retreating blade stall on the aerodynamic behavior of the following rotor-blade sections. The experimental simulation is considered in a 2D flow configuration constituted by a first emitting airfoil E, oscillating through stall before a second receiving airfoil R set at different transversal positions in the wake. The results obtained show that the aerodynamic behavior of R could be more easily approached by the study of an isolated airfoil submitted to simultaneous fluctuations of amplitude velocity V and incidence alpha. For transversal positions of E and R generating instantaneous variations of V and alpha sufficiently large, a dynamic stall occurs on R and its associated unsteady features are pointed out by the typical behavior of forces, moments and pressures (stall delay, vortex shedding, . . .). When transversal positions of E and R generate smaller variations of V and alpha in the impinging wake, nonlinear effects are yet present on the forces and moments behavior of R. In this last case, a simple model is proposed for calculation of such unsteady characteristics on R. Author

**A85-40781#**

### UNSTEADY TRANSONIC FLOW OVER OSCILLATING SLENDER BODIES

C. AYGUN and S. N. TIWARI (Old Dominion University, Norfolk, VA) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 10 p. refs  
(AIAA PAPER 85-1709)

The unsteady transonic small disturbance equation for an oscillating slender body is obtained from the full potential equation using a perturbation analysis. The time-dependent body-boundary condition is reduced to a simpler form by matching the outer and inner flows. An expression for the time-dependent pressure coefficient is derived using a matching principle. Unsteadiness is imposed on the flow at the body axis by considering an axially oscillating slender body, and the resulting unsteady equations are solved using a modified form of the alternating direction, implicit technique. The time-dependent surface pressure distributions and sonic regions are calculated for different Mach numbers in the transonic range and for different values of the reduced frequency

parameter to examine its effects on the unsteadiness features of the flow field. C.D.

#### A85-40782#

##### UNSTEADY TRANSONIC FULL POTENTIAL SOLUTIONS FOR AIRFOILS ENCOUNTERING VORTICES AND GUSTS

L. N. SANKAR (Georgia Institute of Technology, Atlanta) and J. B. MALONE (Lockheed-Georgia Co., Marietta, GA) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 7 p. Research supported by the Lockheed-Georgia Independent Research and Development Program. refs (AIAA PAPER 85-1710)

A solution procedure is described for incorporating weak rotational effects into an existing full potential solver. In this approach, the velocity field is assumed to be made up of two components, one arising from an irrotational flow, and the other arising from external disturbances such as passing vortices and gusts. The velocity field due to the rotational effects obeys a simple Poisson's equation and may be computed using finite difference techniques or the Biot-Savart law. The irrotational part of the velocity flow field satisfies a second order hyperbolic partial differential equation. Numerical solutions are presented for the following cases to establish the accuracy and reliability of this procedure: (1) A NACA 0012 airfoil encountering a passing point vortex in transonic flow, (2) A NACA 64A006 airfoil encountering a passing point vortex in transonic flow, (3) Response of a NACA 0012 airfoil to a travelling, sinusoidal gust of small amplitude. In all cases, comparisons are given with available numerical data.

Author

A85-40783\*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

##### UNSTEADY TRANSONIC FLOW CALCULATIONS FOR INTERFERING LIFTING SURFACE CONFIGURATIONS

J. T. BATINA (NASA, Langley Research Center, Hampton, VA) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 12 p. refs (AIAA PAPER 85-1711)

Unsteady transonic flow calculations are presented for aerodynamically interfering lifting surface configurations. Calculations are performed by extending the XTRAN3S (Version 1.5) unsteady transonic small-disturbance code to allow the treatment of an additional lifting surface. The research was conducted as a first-step toward developing the capability to treat a complete flight vehicle. Grid generation procedures for swept tapered interfering lifting surface applications of XTRAN3S are described. Transonic calculations are presented for wing-tail and canard-wing configurations for several values of mean angle of attack. The effects of aerodynamic interference on transonic steady pressure distributions and steady and oscillatory spanwise lift distributions are demonstrated. Results due to wing, tail, or canard pitching motions are presented and discussed in detail. Author

A85-40804\*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

##### JUNCTURE FLOW MEASUREMENTS USING LASER VELOCIMETRY

L. R. KUBENDRAN (NASA, Langley Research Center, Hampton, VA) and J. SCHEIMAN American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 8 p. refs (AIAA PAPER 85-1612)

The turbulent flow in a simulated wing-fuselage juncture has been investigated using Laser Velocimetry. The juncture was simulated by a splitter plate with an unswept wing model mounted perpendicular to it. The use of sharp wing leading edge results in the elimination of separation ahead of leading edge, and hence the separation vortex. Secondary flow induced by Reynolds stress gradients is the main source of vortical motion in the juncture formed by the plate and the flat surface of the wing, whereas in the juncture formed by the plate and the circular arc surface of

the wing, streamwise vorticity is generated because of the presence of lateral curvature in the flow field. The results of this study indicate that fillets in the juncture can improve the flow characteristics near the wing trailing edge. Author

#### A85-40812#

##### INVISCID MODELING OF TURBOMACHINERY WAKE TRANSPORT

H. D. JOSLYN, J. R. CASPAR, and R. P. DRING (United Technologies Research Center, East Hartford, CT) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 9 p. Research supported by the United Technologies Corp. refs (AIAA PAPER 85-1132)

The problem of unsteady wake-airfoil interaction and wake transport is of importance in nearly all fluid mechanical devices that involve rotating machinery. In this study, an inviscid airfoil-to-airfoil potential flow analysis is used to predict the transport of the wakes of upstream stators through both rotating compressor and turbine airfoil passages. The dependence of wake rotation on airfoil lift and the dependence of wake distortion on airfoil geometry are both shown. Flow visualization results obtained in both a large scale compressor and a large scale turbine rig show good comparison with the predictions of the inviscid model. Author

A85-40817\*# Douglas Aircraft Co., Inc., Long Beach, Calif.

##### CALCULATION OF COMPRESSIBLE FLOW ABOUT THREE-DIMENSIONAL INLETS WITH AUXILIARY INLETS, SLATS AND VANES BY MEANS OF A PANEL METHOD

J. L. HESS, D. M. FRIEDMAN, and R. W. CLARK (Douglas Aircraft Co., Long Beach, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 9 p. refs

(Contract NAS3-22250)

(AIAA PAPER 85-1196)

An efficient and user-oriented method has been constructed for calculating flow in and about complex inlet configurations. Efficiency is attained by: the use of a panel method, a technique of superposition for obtaining solutions at any inlet operating condition, and employment of an advanced matrix-iteration technique for solving large full systems of equations, including the nonlinear equations for the Kutta condition. User concerns are addressed by the provision of several novel graphical output options that, taken together, yield a more complete comprehension of the flowfield than had been possible previously. Examples of these features are presented for some complicated configurations, and where possible, comparisons are made between calculation and experiment. Author

A85-40819\*# Douglas Aircraft Co., Inc., Long Beach, Calif.

##### LOW-SPEED AERODYNAMIC TEST OF AN AXISYMMETRIC SUPERSONIC INLET WITH VARIABLE COWL SLOT

A. G. POWELL, H. R. WELGE (Douglas Aircraft Co., Long Beach, CA), and C. J. TREFNY (NASA, Lewis Research Center, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 5 p. Previously announced in STAR as N85-26710.

(AIAA PAPER 85-1210)

The experimental low-speed aerodynamic characteristics of an axisymmetric mixed-compression supersonic inlet with variable cowl slot are described. The model consisted of the NASA P-inlet centerbody and redesigned cowl with variable cowl slot powered by the JT8D single-stage fan simulator and driven by an air turbine. The model was tested in the NASA Lewis Research Center 9- by 15-foot low-speed tunnel at Mach numbers of 0, 0.1, and 0.2 over a range of flows, cowl slot openings, centerbody positions, and angles of attack. The variable cowl slot was effective in minimizing lip separation at high velocity ratios, showed good steady-state and dynamic distortion characteristics, and had good angle-of-attack tolerance. Author



**A85-40820#**

## **A MACH 2.0 PLUS SUPERSONIC INLET STUDY USING THE NAVIER-STOKES EQUATIONS**

L. G. HUNTER, J. M. TRIPP, and D. G. HOWLETT (General Dynamics Corp., Fort Worth, TX) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 12 p. refs

(AIAA PAPER 85-1211)

The 3-D, unsteady, compressible Navier-Stokes equations were numerically solved for the flowfield about three external-compression inlet configurations. Configuration 1 was a generic Mach 2.2 variable-geometry two-ramp inlet with a bleed slot. Configuration 2 was an F-16/79 inlet at Mach 2.0 with porous-ramp bleed and slot bleed. For these configurations, two different approaches were used to model the bleed. Configurations 1 and 2 were modeled by using three lateral planes in the 3-D code with symmetry around the center plane, which provides an equivalent 2-D solution. Configuration 3 was an axisymmetric spike inlet at Mach 2.2 at zero degrees angle of attack. A full 3-D solution was obtained for this configuration. For configurations 2 and 3, the computed surface pressures are in good agreement with the experimental data for cases with and without bleed.

Author

**A85-40822#**

## **EXTENSION OF CFD TECHNOLOGY USED TO DESIGN THE JVX INLET**

G. C. PAYNTER, J. L. KONCSEK (Boeing Military Airplane Co., Seattle, WA), B. TURCZENIUK (Boeing Vertol Co., Philadelphia, PA), and F. A. DVORAK (Analytical Methods, Inc., Bellevue, WA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 13 p. refs

(AIAA PAPER 85-1215)

A joint services program is underway to develop a tilt rotor vertical lift aircraft, the V-22 Osprey, previously the JVX, for amphibious assault, combat search and rescue, special operations, and electronic warfare. The engine inlets for this aircraft must supply air to the engines with high recovery and low distortion under all operational modes without an increase in overall aircraft drag at cruise due to inlet flow spillage. In addition, the inlet must prevent sand ingested into the inlet from passing through the engine. This paper describes the CFD based design procedure and validation testing for an initial inlet design. It also provides an assessment of the success of the procedure and describes work in progress to improve the procedure for subsequent design studies.

Author

**A85-40829#**

## **SIMULATION OF NACELLE-AFTERBODY/EXHAUST-JET FLOWFIELDS USING A THREE-DIMENSIONAL NAVIER-STOKES ALGORITHM**

J. VADYAK (Lockheed-Georgia Co., Marietta, GA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 14 p. Research supported by Lockheed-Georgia Co. refs

(AIAA PAPER 85-1283)

A computer analysis has been developed for calculating steady (or unsteady) three-dimensional nacelle-afterbody/exhaust-jet flowfields. This algorithm can compute the flowfield about axisymmetric or arbitrary asymmetric afterbody configurations at zero or nonzero incidence at subsonic, transonic, or supersonic free-stream speeds. Flowfield solutions can be obtained for a nacelle (or fuselage) afterbody with a solid plume simulator, a turbu-jet (single exhaust jet) configuration, or a turbofan coaxial exhaust jet configuration. The algorithm can solve either the Euler equations for inviscid flow, the thin-shear-layer Navier-Stokes equations for viscous flow, or the full Navier-Stokes equations for viscous flow. The flowfield solution is determined on a body-fitted numerically-generated computational grid. A fully-implicit alternating-direction-implicit method is employed for solution of the finite-difference equations. Numerical results and correlations with experimental data are presented to illustrate application of the analysis.

Author

**A85-40930#**

## **UNSTEADY VISCOUS FLOW ROUND MOVING CIRCULAR CYLINDERS AND AIRFOILS**

Y. LECOINTE and J. PIQUET (Ecole Nationale Supérieure de Mécanique, Nantes, France) IN: Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers. New York, AIAA, 1985, p. 38-49.

(Contract DRET-83-473)

(AIAA PAPER 85-1490)

The unsteady two-dimensional Navier-Stokes Equations written in their vorticity - stream function formulation are solved numerically by means of compact schemes for several geometries (circular cylinder and airfoils). A detailed study of superimposed motions of a circular cylinder at high reduced amplitudes is first considered. The flow round a NACA0012 airfoil immersed in a steady laminar stream is also investigated. Besides a detailed study of the impulsively started problem for several angles of attack corresponding to massive separation, superimposed motions are studied.

Author

**A85-40934\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

## **CONVERGENCE ACCELERATION FOR A THREE-DIMENSIONAL EULER/NAVIER-STOKES ZONAL APPROACH**

J. FLORES (NASA, Ames Research Center, Moffett Field, CA) IN: Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers. New York, AIAA, 1985, p. 75-86. refs

(AIAA PAPER 85-1495)

A fast diagonal algorithm is coupled with a zonal approach to solve the three-dimensional Euler/Navier-Stokes equations. Transonic viscous solutions are obtained on a 150,000 point mesh for a NACA 0012 wing. The new computational approach yields a speedup by as much as a factor of 40 over the standard Beam-Warming algorithm/zonal method originally coded. A three-order-of-magnitude drop in the L2-norm of the residual requires approximately 500 iterations, which takes about 45 min of CPU time on a Cray-XMP. The numerically computed solutions are in good agreement with experimental results. Effects on convergence rate owing to increasing the zonal boundary overlap regions, different stretching distributions in the viscous regions, and different CFL values are also explored.

Author

**A85-40935#**

## **NUMERICAL STUDY OF A NON-CENTERED SCHEME WITH APPLICATION TO AERODYNAMICS**

M. BORREL and J. L. MONTAGNE (ONERA, Chatillon-sous-Bagneux, France) IN: Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers. New York, AIAA, 1985, p. 88-97. refs

(AIAA PAPER 85-1497)

An improved second order extension of Godunov scheme has been developed for solving the unsteady two-dimensional Euler equations with application to transonic and supersonic flows. The method is based upon the ideas already introduced by van Leer for the one-dimensional case. The second order accuracy is achieved by means of slopes calculation. The multi-dimensional version makes use of an explicit predictor-corrector scheme through a finite-volume approach. A study of the stability and of the boundary conditions treatment is presented. A comparison between three upwind flux formulas is made on the problem of an unsteady flow past a wedge in a channel. Two aerodynamic applications are presented: the first one concerns a flow past an airfoil and the second one, an axisymmetric flow through an air-intake. The quality of the numerical results obtained demonstrates the interest of this scheme in aerodynamics and makes it possible to consider more complex applications.

Author

A85-40940#

**NAVIER-STOKES SOLUTION FOR HYPERSONIC FLOW OVER AN INDENTED NOSETIP**

B. MUELLER (DFVLR, Institut fuer theoretische Stroemungsmechanik, Goettingen, West Germany) IN: Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers. New York, AIAA, 1985, p. 141-149. DFG-supported research. refs (AIAA PAPER 85-1504)

The axisymmetric Navier-Stokes equations are solved by means of the implicit factorized Beam and Warming scheme to simulate laminar hypersonic flow over a severely indented blunt nosetip at zero angle of attack. An efficient linearization of the mixed derivatives and a new form of convergence acceleration to the steady state are employed. The relation between the present finite-difference approach and the finite volume technique is outlined. The blunt body code is fully vectorized on the CRAY-1S vector computer, and verified for attached supersonic and hypersonic flow over simple convex components. The computed Navier-Stokes and thin-layer solutions for hypersonic flow at high Reynolds numbers over a reentry vehicle indented nosetip with a large separation region are practically identical, and in good agreement with other numerical and experimental data. Author

A85-40944#

**NAVIER-STOKES SOLUTION OF THE FLOW FIELD AROUND A COMPLETE AIRCRAFT**

J. S. SHANG and S. J. SCHERR (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) IN: Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers. New York, AIAA, 1985, p. 182-191. refs (AIAA PAPER 85-1509)

The present effort represents a first attempt of numerical simulation of the flow field around a complete aircraft configuration utilizing the Reynolds averaged Navier-Stokes equations. The numerical solution generated for the experimental aircraft concept X24C-10D at a Mach number of 5.95 not only exhibited accurate prediction of detailed flow properties but also of the integrated aerodynamic coefficients. In addition, the present analysis demonstrated that a page structure of data collected into cyclic blocks is an efficient and viable means for processing the Navier-Stokes equations on the CRAY XMP-22 computer with external memory device. Author

A85-40945#

**COMPUTATION OF THREE-DIMENSIONAL VISCOUS TRANSONIC FLOWS WITH THE LU FACTORED SCHEME**

S. OBAYASHI (Tokyo, University, Japan) and K. FUJII (National Aerospace Laboratory, Chofu, Tokyo, Japan) IN: Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers. New York, AIAA, 1985, p. 192-202. refs (AIAA PAPER 85-1510)

The LU-Alternating Direction Implicit factored scheme has been successfully applied to solve the three-dimensional compressible 'thin layer' Navier-Stokes equations. The computations are carried out for the slightly supersonic flow over a hemisphere cylinder at high incidence and the transonic flow over a swept wing. To simulate these complicated flow fields, fine grid distributions of up to about 200,000 points were used on a new Japanese supercomputer of 1 GFLOPS. The total CPU time for each case was less than two hours. The result for the flow over a hemisphere cylinder at high incidence revealed the detailed structure of the vortical flow field. The result for the flow over a swept wing shows that the three-dimensional shock-induced separation is well captured. These results indicate the capability of the present code for three-dimensional, complicated flow field simulations. Author

A85-40948\*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**IMPLICIT TVD SCHEMES FOR HYPERBOLIC CONSERVATION LAWS IN CURVILINEAR COORDINATES**

H. C. YEE (NASA, Ames Research Center, Moffett Field, CA) and A. HARTEN (Tel Aviv University, Israel; California, University, Los Angeles) IN: Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers. New York, AIAA, 1985, p. 228-241. refs (AIAA PAPER 85-1513)

The Harten (1983, 1984) total variation-diminishing (TVD) schemes, constituting a one-parameter explicit and implicit, second-order-accurate family, have the property of not generating spurious oscillations when applied to one-dimensional, nonlinear scalar hyperbolic conservation laws and constant coefficient hyperbolic systems. These methods are presently extended to the multidimensional hyperbolic conservation laws in curvilinear coordinates. Means by which to linearize the implicit operator and solution strategies, in order to improve the computation efficiency of the implicit algorithm, are discussed. Numerical experiments with steady state airfoil calculations indicate that the proposed linearized implicit TVD schemes are accurate and robust. O.C.

A85-40949#

**TRANSONIC FLOWS ABOUT OSCILLATING AIRFOILS USING THE EULER EQUATIONS**

A. JAMESON and V. VENKATKRISHNAN (Princeton University, NJ) IN: Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers. New York, AIAA, 1985, p. 242-253. refs (AIAA PAPER 85-1514)

Transonic flow over a harmonically oscillating airfoil is computed by solving the two-dimensional Euler equations in integral form using the finite volume scheme. The dissipation terms are constructed according to theory of total variation diminishing schemes in order to obtain good resolution of shock fronts. Nonreflecting boundary conditions have been utilized in the farfield. It is seen that total variation diminishing schemes are well suited for unsteady flow problems, while the finite volume formulation allows a very simple treatment of deforming meshes. Author

A85-40952\*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**NAVIER-STOKES SIMULATIONS OF ROTOR-STATOR INTERACTION USING PATCHED AND OVERLAID GRIDS**

M. M. RAI (NASA, Ames Research Center, Moffett Field, CA) IN: Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers. New York, AIAA, 1985, p. 282-298. refs (AIAA PAPER 85-1519)

An accurate numerical analysis of the flows associated with rotor-stator configurations in turbomachinery can be very helpful in optimizing the performance of turbomachinery. In this study the unsteady, thin-layer, Navier-Stokes equations are solved using a system of patched and overlaid grids for a rotor-stator configuration of an axial turbine. The equations necessary for an accurate transfer of information between the several grids are briefly described within the framework of an iterative, implicit algorithm. Results in the form of Mach number contours, time-averaged pressures, unsteady pressures, amplitudes, and phase are presented. The numerical results are also compared with experimental data and the agreement is found to be good. Author

## 02 AERODYNAMICS

**A85-40957\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### **A SELF-ADAPTIVE-GRID METHOD WITH APPLICATION TO AIRFOIL FLOW**

K. NAKAHASHI and G. S. DEIWERT (NASA, Ames Research Center, Moffett Field, CA) IN: Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers. New York, AIAA, 1985, p. 340-350. refs (AIAA PAPER 85-1525)

A self-adaptive-grid method is described that is suitable for multidimensional steady and unsteady computations. Based on variational principles, a spring analogy is used to redistribute grid points in an optimal sense to reduce the overall solution error. User-specified parameters, denoting both maximum and minimum permissible grid spacings, are used to define the all-important constants, thereby minimizing the empiricism and making the method self-adaptive. Operator splitting and one-sided controls for orthogonality and smoothness are used to make the method practical, robust, and efficient. Examples are included for both steady and unsteady viscous flow computations about airfoils in two dimensions, as well as for a steady inviscid flow computation and a one-dimensional case. These examples illustrate the precise control the user has with the self-adaptive method and demonstrate a significant improvement in accuracy and quality of the solutions.

Author

**A85-40962#**

### **NEWTON SOLUTION OF DIRECT AND INVERSE TRANSONIC EULER EQUATIONS**

M. GILES, M. DRELA, and W. T. THOMPSON, JR. (MIT, Cambridge, MA) IN: Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers. New York, AIAA, 1985, p. 394-402. refs (Contract F49620-78-C-0084) (AIAA PAPER 85-1530)

The present method for the rapid solution of both direct and inverse transonic flow problems having strong viscous-inviscid interactions combines a finite volume formulation of the Euler equations, in whose intrinsic grid one set of lines corresponds to streamlines, with an integral formulation of the compressible boundary layer equations. These nonlinear equations are then solved by Newton's method, with solution of the linearized system by Gaussian elimination. Attention is presently given to the results thus obtained for a shock-free supercritical blade cascade, a compressor cascade with shock, a supercritical airfoil with a strong shock-boundary layer interaction, and the redesign of a supercritical airfoil, including boundary layer coupling effects.

O.C.

**A85-40964\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### **A NEW FINITE ELEMENT APPROACH FOR PREDICTION OF AEROTHERMAL LOADS - PROGRESS IN INVISCID FLOW COMPUTATIONS**

K. S. BEY (NASA, Langley Research Center, Hampton, VA), E. A. THORNTON, P. DECHAUMPHAI (Old Dominion University, Norfolk, VA), and R. RAMAKRISHNAN IN: Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers. New York, AIAA, 1985, p. 411-424. refs (AIAA PAPER 85-1533)

Recent progress in the development of finite element methodology for the prediction of aerothermal loads is described. Two dimensional, inviscid computations are presented, but emphasis is placed on development of an approach extendable to three dimensional viscous flows. Research progress is described for: (1) utilization of a commercially available program to construct flow solution domains and display computational results, (2) development of an explicit Taylor-Galerkin solution algorithm, (3) closed form evaluation of finite element matrices, (4) vector computer programming strategies, and (5) validation of solutions. Two test problems of interest to NASA Langley aerothermal research are studied. Comparisons of finite element solutions for Mach 6 flow with other solution methods and experimental data

validate fundamental capabilities of the approach for analyzing high speed inviscid compressible flows.

Author

**A85-40965#**

### **AN IMPLICIT ALGORITHM FOR SOLVING 2D ROTATIONAL FLOW IN AN AIRCRAFT ENGINE FAN FRAME**

M. G. TURNER and J. S. KEITH IN: Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers. New York, AIAA, 1985, p. 425-437. refs (AIAA PAPER 85-1534)

A flow field prediction method is presented which produces good accuracy with a coarse computational grid. The method is applied to the rotational flow aft of a fan rotor in a high bypass turbofan engine where blockage of large structural pylons can cause significant circumferential static and total pressure variations. The complete analysis of the flow field, which usually contains many airfoils, requires that the flow distribution about each individual airfoil be predicted with few grid points. The method incorporates a finite volume form of the continuity equation, an integral form of the cross-stream momentum equation and is formulated to ensure an accurate spatial representation of entropy and stagnation enthalpy. Results are presented for a centrifugal impeller, the Hobson II cascade, and the General Electric/NASA Energy Efficient Engine fan frame.

Author

**A85-40966#**

### **EXTERNAL COMPRESSION INLET PREDICTIONS USING AN IMPLICIT, UPWIND, MULTIPLE ZONE APPROACH**

R. H. BUSH (McDonnell Aircraft Co., St. Louis, MO) IN: Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers. New York, AIAA, 1985, p. 438-447. refs (AIAA PAPER 85-1521)

The present zonal methodology for existing time-dependent numerical codes is based on boundary conditions that are currently popular in treatments of inflow and outflow boundaries, and, since it may be characterized as a modification of the boundary conditions with a scheme for communicating between zones, it is easily incorporated into numerical codes. The methodology can be extended to three dimensions, and provides a straightforward means for the computation of complex geometric configurations by subdividing the computational domain into a series of simple zones. The methodology is used to compute the performance of an external compression inlet, for which it yielded detailed data on such inherently two-dimensional phenomena as boundary layer behavior and cowl lip flows.

O.C.

**A85-40967#**

### **3-D FINITE ELEMENT SOLUTION OF STEADY EULER TRANSONIC FLOW BY STREAM VECTOR CORRECTION**

F. EL DABAGHI (Institut National de Recherche en Informatique et en Automatique, Le Chesnay, France), O. PIRONNEAU (Paris XIII, Université, Villetaneuse, France), J. PERIAUX, and G. POIRIER (Avions Marcel Dassault Breguet Aviation, Saint-Cloud, France) AIAA, Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985. 13 p. Sponsorship: Service Technique des Programmes Aeronautiques. refs (Contract STPA-84,95,003) (AIAA PAPER 85-1532)

Based on the Helmholtz decomposition of a 3-D velocity field into a scalar potential and a stream vector, a generalized potential approach for solving the steady compressible Euler equations, in which the stream vector is interpreted as a correction to the transonic potential flow, is presented. Consideration is given to the variational formulations, the characteristic methods for transport of entropy and helicity variables, a finite-element method to compute the stream vector correction, least squares to treat nonlinearities, and domain decomposition methods for local entropy correction. The simulation of subsonic and transonic rotational nonlifting 2-D and 3-D flows in a nozzle and around a portion of a wing, is described and compared with other Euler solvers.

M.D.

A85-40981#

**AERODYNAMIC CHARACTERISTICS OF SWEEPED PROPELLERS**  
M. KOBAYAKAWA, H. ONUMA, M. NISHIDA, A. OHARA, and Y. KAWAKAMI Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 363, 1984, p. 232-241. In Japanese, with abstract in English. refs

The vortex lattice method is applied to calculations of the aerodynamic characteristics of propellers. A blade of the propeller is divided into many trapezoidal panels, and each panel is represented by a spiral horse shoe vortex in which a bound vortex is placed on the 1/4-chord line of the panel, and a pair of wake vortices is emitted from both ends of the bound vortex. The circulation strength of these vortices can be obtained by the boundary conditions. Thrust, torque and efficiency of the propeller are obtained by summing up all forces. The effect of displacement velocity, the effect of compressibility by Prandtl-Glauert similarity rule and the effect of drag force introduced into the force calculations using experimental data are examined. Furthermore, utilizing the efficiency of each panel, total efficiency of the propeller is improved by increasing or decreasing pitch angle of the blade. The following results are derived: (1) the power coefficients agree well with the experimental values for the conventional type of propeller, (2) the efficiencies are larger than the experimental values for all types of propeller. Author

A85-40982#

**FLOW PAST BLUNT OBSTACLES OF CIRCULAR SECTION PLACED ON A PLANE BOUNDARY**

S. OKAMOTO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 363, 1984, p. 242-248. In Japanese, with abstract in English. refs

The paper describes an experimental study of the flow past a blunt obstacle placed on a plane boundary. The experiment was carried out in an N.P.L. blow-down type wind-tunnel having a working section of 400 mm x 400 mm x 2000 mm at Reynolds number  $4.74 \times 10,000$ . The surface-pressure distributions on a sphere, hemisphere cylinder and circular cylinder were measured and the drag and lift coefficients were determined by integration of the surface pressure. The vortices generated in the flow-field around an obstacle have also been observed. Since a hemisphere cylinder is seen to be a hybrid of a sphere and a circular cylinder, the results for hemisphere-cylinder were compared with those for a sphere and a circular cylinder. Author

A85-40988#

**NUMERICAL CALCULATION OF UNSTEADY TRANSONIC POTENTIAL FLOW OVER THREE-DIMENSIONAL WINGS**

K. ISOgai Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 365, 1984, p. 319-330. In Japanese. refs

The difference method based on the full potential equation, and unsteady and steady transonic full potential 3D code (USTF3) are applied to numerical simulation of transonic flutter of three-dimensional wings. The USTF3 is applied to numerical simulation of transonic flutter of supercritical wings of NASA. This method is limited to the case of the relatively weak impact wave. Steady pressure distribution of Onera M6 wing and unsteady pressure distribution of Nora wing are analyzed. Calculated and measured values of flutter boundary are compared. A block diagram indicating the calculating sequence of flutter is included. S.H.

A85-40992#

**RECENT TENDENCY OF FLOW FIELD CALCULATIONS WITH THREE-DIMENSIONAL SEPARATION AROUND HIGH VELOCITY VEHICLE**

S. NOMURA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 365, 1984, p. 351-359. In Japanese. refs

Developments in numerical calculations of flows with three-dimensional separation around high velocity vehicles are summarized. Various flow models, including the Maskel structure are characterized. Nonrepeating ADI solution of the Navier-Stokes

equation as applied to the flow around a high velocity vehicle, and flow in spinning and coning motions are discussed. S.H.

A85-40996#

**A COMMENT ON CONTROLLED DIFFUSION AIRFOIL**

K. HASHIMOTO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 366, 1984, p. 394, 395. In Japanese. refs

Characteristics of controlled diffusion airfoil (CDA) cascade are described. CDA is being used in compressors and turbines of fan jet engines of commercial aircraft; it can achieve increased loading and high critical inlet Mach number. In order to construct the reaction turbine cascade, an optional design method defining directly velocity distribution on the wing surface has been developed. It was found that two dimensional high velocity and cyclic cascades using this cascade provided similar results to that of compressor cascades. S.H.

A85-40999#

**INTERACTION BETWEEN SHOCK WAVES AND BOUNDARY LAYERS INDUCED BY SHARP FIN**

N. SAIDA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 366, 1984, p. 403-409. In Japanese, with abstract in English. refs

The paper presents an experimental study of shock wave/turbulent boundary-layer interaction induced by a sharp fin placed normal to the side wall of the wind tunnel. The experiments were carried out in a supersonic wind tunnel at free stream Mach numbers of 1.98 and 2.48. Corresponding free stream Reynolds numbers per meter were  $4.1 \times 10^7$  and  $2.7 \times 10^7$  for the former case and  $4.1 \times 10^7$  for the latter case. A set of 3 fin models with wedge type leading edge of 20, 30 and 40 deg half angle were used in this study. Surface static pressure measurements, oil flow studies and Schlieren photographs of the flow field were made. It was found that, the separation shock angle and the pressure ratio through separation are insensitive to the shape of fin's leading edge. The length of the upstream influence point and the separation point measured along the centerline from the fin's leading edge were found to increase linearly with the increase of wedge angle. Furthermore, with the increase of wedge angle, the pressure distribution became qualitatively similar to the hemi-cylindrical blunt fin case. Author

A85-41007#

**STUDIES ON THE FLOW IN SUPERSONIC AXIAL-FLOW COMPRESSOR ROTOR. VI - A POSSIBILITY OF TWO-DIMENSIONAL SUPERSONIC SECTION HAVING QUASI-AXISYMMETRIC FLOWS WHICH SATISFY SIMPLIFIED RADIAL EQUILIBRIUM**

T. HASHIMOTO and S. OTSUKA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 367, 1984, p. 477-481. In Japanese, with abstract in English. refs

A85-41011#

**INVISCID HYPERSONIC FLOW AROUND A CONICAL FLAT-TOP WING-BODY COMBINATION**

T. KIMURA, M. NISHIO, and M. KOTAKE Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 368, 1984, p. 511-517. In Japanese, with abstract in English. refs

The steady hypersonic flow around a slender conical flat-top wing-body has been solved by applying the equivalence principle, which is that the steady hypersonic flow past a slender body is equivalent to the unsteady flow in a plane. The conical flat-top wing-body becomes the problem of the expanding motion of a hemi-cylinder with a plane wing. The flowfield of this expanding body has been solved by means of a conformal transformation and a superposition technique. Moreover, the other problems such as small angles of attack, vortices, shock shape, etc., have also been solved and the flow around the expanding body has been visualized. The experimental results agree well with the theoretical ones. Author

## 02 AERODYNAMICS

A85-41012#

### A NUMERICAL CALCULATION OF PROPELLER PERFORMANCE AT STATIC CONDITION AND ITS COMPARISON WITH EXPERIMENT

M. IWASAKI and K. WATANABE Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 368, 1984, p. 518-525. In Japanese, with abstract in English. refs

The aerodynamic performance of a four-bladed propeller at static conditions is calculated by a vortex factor theory assuming an infinite number of blades and considering the slipstream deformation. The thrust and torque distributions along blades are obtained by measuring the static pressure over the blade surface. Agreement of the numerical results with the experimental ones is fairly good and some information about the behavior of the slipstream is given. Application of the method to the estimation of helicopter rotor performance at hovering also shows tolerable results.

Author

A85-41024#

### FLOW PAST RECTANGULAR CYLINDER OF SQUARE SECTION PLACED ON A PLANE BOUNDARY

S. OKAMOTO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 370, 1984, p. 661-665. In Japanese, with abstract in English. refs

An experimental study of the flow past a rectangular cylinder of square section placed on a plane boundary is discussed. The experiment was carried out in an NPL blowdown type wind-tunnel having a working section of 500 mm x 500 mm x 2000 mm at Reynolds number  $4.74 \times 10,000$ . The surface-pressure distributions on the rectangular cylinders were measured, and the vortices of two kinds generated in the flow-field around a rectangular cylinder have also been observed. It is found that the flow patterns and vortices around a rectangular cylinder of  $W/D$  (ratio of length to width) = 1.5 is different from those for the  $W/D = 0.06 - 1.0$  range.

Author

A85-41026#

### FAN AND COMPRESSOR TECHNOLOGY

S. NAGANO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 371, 1984, p. 677-682. In Japanese. refs

Recent developments in aerodynamics of axial flow fans and compressors for aircraft engines are analyzed. New technologies for improving engine performance such as supercritical airfoil, wide chord blade, and three-dimensional cascade, and consideration of the outlet distortion are characterized. Time-marching methods for analyzing flow in airfoils and measurements using a laser flow meter are compared. Future potential of laser holography for measuring flow in supersonic airfoils is stressed.

S.H.

A85-41055\*# National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

### NATURAL LAMINAR FLOW HITS SMOOTHER AIR

B. J. HOLMES (NASA, Langley Research Center, Hampton, VA) Aerospace America (ISSN 0740-722X), vol. 23, July 1985, p. 60, 61, 77.

Natural laminar flow (NLF) may be attained in aircraft with lower cost, weight, and maintenance penalties than active flow laminarization by means of a slot suction system. A high performance general aviation jet aircraft possessing a moderate degree of NLF over wing, fuselage, empennage and engine nacelles will accrue a 24 percent reduction in total aircraft drag in the cruise regime. NASA-Langley has conducted NLF research centered on the use of novel airfoil profiles as well as composite and milled aluminum alloy construction methods which minimize three-dimensional aerodynamic surface roughness and waviness. It is noted that higher flight altitudes intrinsically reduce unit Reynolds numbers, thereby minimizing turbulence for a given cruise speed.

O.C.

A85-41228

### COMPUTER-SYSTEM STRUCTURE FOR SOLVING FLOW PROBLEMS - A COMPLEX APPROACH TO DESIGN [O STRUKTURE VYCHISLITELIA DLIYA RESHENIYA ZADACH OBTEKANIIA KOMPLEKSNIYI PODKHOD K PROEKTIROVANIUI]

A. N. ANDRIANOV, K. I. BABENKO, A. V. ZABRODIN, I. B. ZADYKHAILO, E. I. KOTOV et al. IN: Computational processes and systems. Moscow, Izdatel'stvo Nauka, 1985, p. 13-62. In Russian. refs

Requirements relating to the development of a problem-oriented supercomputer intended for the solution of problems of hydroaerodynamics with reference to aircraft design are examined. Attention is given to the architecture of a supercomputer system with a high degree of parallelism which satisfies speed (one-billion to ten-billion operations per second) and memory requirements (100-million to one-billion words). Aspects of software development for supercomputers are considered, and the creation of a stable programming language is discussed.

B.J.

A85-41275

### ASYMPTOTIC CALCULATIONS OF GASDYNAMIC QUANTITIES NEAR THE SEPARATION OF A LIMITING SHOCK LAYER [ASIMPTOTICHESKIE OTSENKI GAZODINAMICHESKIKH VELICHIN V OBLASTI OTRYVA PREDEL'NOGO UDARNOGO SLOIA]

V. N. ENGELGART Leningradskii Universitet, Vestnik, Matematika, Mekhanika, Astronomiia (ISSN 0024-0850), April 1985, p. 115-117. In Russian. refs

The two-dimensional steady hypersonic ideal-gas flow past a smooth convex body is studied for an effective adiabatic exponent approaching unity. The asymptotic structure of the solution in the region behind the separation point of the limiting shock layer is examined.

B.J.

A85-41402#

### A NUMERICAL STUDY OF SPIN EFFECTS ON AXISYMMETRIC FLOW PAST A BODY OF REVOLUTION

K. F. WEBER, T. J. AKAI (Notre Dame, University, IN), and T. J. MUELLER American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 12 p. refs (AIAA PAPER 85-1605)

An implicit-explicit method is used to solve the laminar, compressible Navier-Stokes equations for axisymmetric flow past a body of revolution with and without spin. The flow Reynolds number is  $1.07 \times 10$  to the 6th based on body length, the freestream Mach number  $M_\infty$  is 0.081, and the minimum Rossby number for the spin case is 3.43. The results for flow without spin agree well with experimental data. The low spin rate does not significantly affect the pressure distribution on the body. However, there is a slight overall increase in displacement thickness when the body is spun, and the total velocity profiles (with spin) contain inflexion points.

Author

A85-41403#

### AERODYNAMIC INTERACTIONS BETWEEN A ROTOR AND AIRFRAME IN FORWARD FLIGHT

N. M. KOMERATH, H. M. MCMAHON, and J. E. HUBBARTT (Georgia Institute of Technology, Atlanta) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 10 p. refs (Contract DAAG29-82-K-0094) (AIAA PAPER 85-1606)

Prediction and understanding of the aerodynamic interactions between the rotor and airframe are essential to the improvement of rotorcraft design. Presented herein are results from initial phases of a comprehensive research program which focuses on validating codes for predicting these aerodynamic interactions. Mean and periodic pressures on the surface of a cylindrical body in the wake of a rotor at advance ratios of 0.75 through 2.0, and LDV data on the velocity components below the rotor plane are

presented. The configuration is modeled using a prediction code reported in the literature, and some comparisons are shown.

Author

**A85-41404#**  
**COMPUTATIONAL STUDY OF THREE-DIMENSIONAL WAKE STRUCTURE**

R. HIMENO (Nissan Motor Co., Ltd., Central Engineering Laboratory, Yokosuka, Japan), S. SHIRAYAMA, K. KAMO, and K. KUWAHARA (Tokyo, University, Japan) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 8 p. refs

(AIAA PAPER 85-1617)

Three-dimensional wake structure is studied by numerically solving the incompressible Navier-Stokes equations. The results are visualized by a three-dimensional color graphic system. It was found that a pair of vortex tubes separated from the body plays the most important role in the wake. Near the body the vortex tubes are rather stable; as they flow downstream they gradually become unsteady.

Author

**A85-41408#**  
**VELOCITY MEASUREMENTS IN THE NEAR WAKE OF A HOVERING ROTOR**

N. M. KOMERATH, T. L. THOMPSON, and R. B. GRAY (Georgia Institute of Technology, Atlanta) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 10 p. refs

(Contract DAAG29-82-K-0094)

(AIAA PAPER 85-1675)

Measurements of the velocity field in the near wake of a single-bladed rotor in hover are reported. Techniques and problems involved in making these measurements using a two-channel laser Doppler velocimeter are described. Data are presented on the azimuthal evolution of the velocity field at several locations in the wake. The velocity in the core of the tip vortex is studied using both backscatter and off-axis scatter modes of collecting scattered light. Comparisons are presented between previous analytical and empirical wake profiles and the present measurements. Evidence is shown of suspected secondary vortex structures within the main tip vortex core.

Author

**A85-41411\*#** New Hampshire Univ., Durham.  
**TRANSITION CONTROL BY PERIODIC SUCTION-BLOWING**  
S. BIRINGEN, W. E. NUTT, and M. J. CARUSO (New Hampshire, University, Durham) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 13 p. refs

(Contract NAG1-462)

(AIAA PAPER 85-1700)

The applicability of active control of transition by period suction-blowing is investigated via direct numerical simulations of the Navier-Stokes equations. The time-evolution of finite-amplitude disturbances in plane channel flow is compared in detail with and without control. The analysis indicates that for relatively small three-dimensional amplitudes, a two-dimensional control effectively reduces disturbance growth rates even for linearly unstable Reynolds numbers. After the flow goes through secondary instability, three-dimensional control seems necessary to stabilize the flow. An investigation of the temperature field suggests that passive temperature contamination is operative to reflect the vorticity dynamics during transition.

Author

**A85-41413#**  
**FLOW AROUND A CIRCULAR CYLINDER IN THE FIRST SUBREGION OF THE CRITICAL RANGE**

H. HIGUCHI, C. FARELL (Minnesota, University, Minneapolis), and H. KIM American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 9 p. refs

(AIAA PAPER 85-1715)

The flow transitions around a smooth circular cylinder in the critical Reynolds number range are experimentally investigated. In the subcritical range the boundary layer exhibits strong, spanwise uniform oscillations with a predominant frequency equal to that of vortex shedding. In the first subregion of the critical range, where  $C_d$  decreases rapidly, the velocity and pressure signals exhibit low frequency, symmetric changes associated with local flow reattachment, coupled with the occurrence of spanwise structures, fixed in space, which produce large spanwise variations in pressure and velocity.

Author

**A85-41415\*#** Old Dominion Univ., Norfolk, Va.  
**COMPUTATION OF TRANSONIC VORTEX FLOWS PAST DELTA WINGS INTEGRAL EQUATION APPROACH**

O. A. KANDIL (Old Dominion University, Norfolk, VA) and E. C. YATES, JR. (NASA, Langley Research Center, Hampton, VA) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 12 p. refs

(Contract NAG1-591)

(AIAA PAPER 85-1582)

The steady full-potential equation is written in the form of Poisson's equation, and the solution of the velocity field is expressed in terms of an integral equation. The solution consists of a surface integral of vorticity distribution on the wing and its free-vortex sheets and a volume integral of source distribution within a volume around the wing and its free-vortex sheets. The solution is obtained through successive iteration cycles. The source distribution is computed by using a mixed finite-difference scheme of the Murman-Cole type. The method is applied to delta wings. Numerical examples show that a conical shock is captured on the suction side of the wing. It is attached to the lower surface of the leading-edge vortex but does not necessarily reach to the wing surface.

Author

**A85-41417\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.  
**A COMPARISON BETWEEN IMPLICIT AND HYBRID METHODS FOR THE CALCULATION OF STEADY AND UNSTEADY INLET FLOWS**

T. J. COAKLEY (NASA, Ames Research Center, Moffett Field, CA) and T. HSIEH (U.S. Navy, Naval Surface Weapons Center, White Oak, MD) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 17 p. refs

(AIAA PAPER 85-1125)

Numerical simulation of steady and unsteady transonic diffuser flows using two different computer codes are discussed and compared with experimental data. The codes solve the Reynolds-averaged, compressible, Navier-Stokes equations using various turbulence models. One of the codes has been applied extensively to diffuser flows and uses the hybrid method of MacCormack. This code is relatively inefficient numerically. The second code, which was developed more recently, is fully implicit and is relatively efficient numerically. Simulations of steady flows using the implicit code are shown to be in good agreement with simulations using the hybrid code. Both simulations are in good agreement with experimental results. Simulations of unsteady flows using the two codes are in good qualitative agreement with each other, although the quantitative agreement is not as good as in the steady flow cases. The implicit code is shown to be eight times faster than the hybrid code for unsteady flow calculations and up to 32 times faster for steady flow calculations. Results of calculations using alternative turbulence models are also discussed.

Author



## 02 AERODYNAMICS

**A85-41419\*#** PEDA Corp., Palo Alto, Calif.

### **THREE DIMENSIONAL CSCM METHOD FOR THE COMPRESSIBLE NAVIER-STOKES EQUATIONS WITH APPLICATION TO A MULTI-NOZZLE EXHAUST FLOWFIELD**

J. BARDINA and C. K. LOMBARD (PEDA Corp., Palo Alto, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 10 p. refs (Contract NAS2-11810) (AIAA PAPER 85-1193)

The effective design of three-dimensional flow systems such as a clustered multinozzle shrouded exhaust system requires detailed analysis of the internal flowfield. It is pointed out that new numerical techniques on the most modern vector computers are making these analyses practicable. In this paper, the upwind differenced implicit conservative supracharacteristics method (CSCM) for three-dimensional viscous flow is presented. The new method is an implicit 'method of planes' symmetric Gauss-Seidel relaxation scheme. The data is conveniently stored on successive planes along the streamwise coordinate, and the system of equations is solved twice in each successive plane of the streamwise coordinate. The developed new three-dimensional compressible Navier-Stokes algorithm combines the best features of the storage and computationally efficient space marching procedures with the generality of time dependent techniques to solve flows with elliptic and streamwise separated flows. G.R.

**A85-41422#**

### **A NUMERICAL METHOD FOR DUCT FLOW WITH BOUNDARY LAYER SEPARATION**

W. PRESZ, JR. (United Technologies Research Center, East Hartford, CT) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 7 p. Research supported by the United Technologies Corp. refs (AIAA PAPER 85-1410)

The computation of viscous subsonic internal flows using streamwise marching procedures has become a useful procedure for analysis of attached duct flow. A model problem of two dimensional, incompressible laminar flow was conducted to determine the feasibility of using similar analyses for partially separated ducts. Based on this model problem study, a new procedure has been developed using streamwise marching with multiple sweeps which shows considerable promise for efficiently predicting the performance of separated subsonic ducts. The multiple sweeps account for upstream viscous interaction effects through pressure gradients generated using the normal or cross flow momentum equation. Solutions were found to converge very rapidly and can be applied locally in the flowfield, as needed, to more accurately obtain pressures, or to simulate regions of flow separation. Thus, potential exists for achieving considerable time and cost savings over full Navier Stokes solvers. Author

**A85-41423\*#** Old Dominion Univ., Norfolk, Va.

### **A PARABOLIZED NAVIER-STOKES ALGORITHM FOR SEPARATED SUPERSONIC INTERNAL FLOWS**

T. CHITSOMBOON, S. N. TIWARI (Old Dominion University, Norfolk, VA), and A. KUMAR (NASA, Langley Research Center, Hampton, VA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 8 p. refs (AIAA PAPER 85-1411)

A stable global-iteration procedure is applied to a fully implicit noniterative parabolized Navier-Stokes algorithm to improve the solutions of the single-sweep method as well as to resolve small separation bubbles due to shock-wave/boundary-layer interactions. A modified form of the FLARE approximation is employed in the separated regions and some requirements for stable iterations are discussed. The results of the global-iteration scheme for two test cases of supersonic internal flows are compared against the results of the single-sweep method as well as the results of the full Navier-Stokes solver. Author

**A85-41608**

### **NUMERICAL ANALYSIS OF AERODYNAMIC CHARACTERISTICS OF AN AEROPLANE WING IN COMPRESSIBLE FLOW**

Z. DZYGADLO and T. X. CHU Journal of Technical Physics (ISSN 0324-8313), vol. 25, no. 2, 1984, p. 191-208. refs

A numerical method for the analysis of aircraft wing aerodynamics is applied to the study of a compressible flow in compressible flow at Mach numbers greater than zero but less than the critical Mach number. A vortex model of the wing is developed to calculate the circulation of the vortices. Analytical solutions are obtained to describe the aerodynamic characteristics of different sections of the wing, taking into account the curvature of the middle line of the airfoil section. The theoretical solutions are compared with numerical results for the TS-11 ISKRA aircraft. I.H.

**A85-41608**

### **AN ANALYTICAL INVESTIGATION OF THE GROUND AND AMBIENT HEAD FLOW INFLUENCE ON THE FREE INLET FLOW INTO A TURBOJET ENGINE**

T. GAJEWSKI Journal of Technical Physics (ISSN 0324-8313), vol. 25, no. 2, 1984, p. 229-240. refs

The effect of additional and ground and ambient head flows on the free inlet flow into a turbojet engine is investigated theoretically. The ranges of free inlet flow are calculated under the influence of the ground and ambient head flow for various speed, based on the model of inlet flow into the TS-11 turbojet engine. The behavior of the stagnation point of the flow is described on the basis of a numerical relation between the flow range and the design parameters of the inlet. The velocity field of free inlet flow separated from the ground at a velocity of 50 m/s is illustrated in a graph. I.H.

**A85-41739**

### **AN IMPROVED KERNEL FUNCTION COMPUTATION IN SUBSONIC UNSTEADY LIFTING SURFACE THEORY**

S. ANDO and M. KATO (Nagoya University, Japan) Computer Methods in Applied Mechanics and Engineering (ISSN 0045-7825), vol. 49, June 1985, p. 343-355. refs

An efficient expression of the kernel function in subsonic lifting surface theory is presented. The singularities of the expression are combined into only three terms, which can be expressed by the original variable rather than a modified one. The expression is used to construct several numerical schemes for lifting surface calculations. Preliminary results of the numerical calculations are found to be superior to those of existing methods for high reduced frequency in a moderate Mach number range. The flow charts used to compute the kernel function are given. I.H.

**A85-41781**

### **UNSTEADY HEAT TRANSFER OF OSCILLATING WAKE FLOWS**

S. KOTAKE and I. AOKI (Tokyo, University, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 1. Tokyo, Gas Turbine Society of Japan, 1984, p. 29-35. refs

In order to study the unsteady heat transfer of oscillating wake flows, the heat transfer characteristics of a cylinder in wake flows behind a cylinder located in oscillating flows were investigated experimentally. The amplitudes of surface temperature, hence local heat transfer coefficient of the cylinder in oscillating wake flows are roughly proportional to those of the main flow velocity and inversely proportional to its frequency, although its time mean is hardly affected by the main flow oscillation. The time-mean and fluctuation of heat transfer coefficient take the maximum at the reattachment of the shear layer separated from the first cylinder, hence the relative position of two cylinders plays an important role on unsteady behavior of heat transfer of the cylinder in the wake flows. Author

A85-41804

**CONTROL OF SECONDARY FLOW IN A TURBINE STAGE - EXPERIMENTAL AND THEORETICAL STUDY**

L. BELIK and J. SKOPEK (Vysoka Skola Strojní a Elektrotechnická, Plzeň, Czechoslovakia) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 345-352. refs

The influence of fluid flow suction through the axial clearance between the nozzle and the moving blades at the root diameter of an impulse turbine stage has been investigated. The results of measurements have confirmed the increase in stage efficiency  $\eta_{TS} = 1.013$  when sucked mass flow has reached  $\Delta \dot{m} / \dot{m} = 0.01$ . Blowing-in of parasitic fluid flow has been clearly connected with reduction of efficiency. In an effort to clarify the experimental results and to confirm the possibility of controlling secondary flow losses in the stage blading, a simple one-dimensional model of flow through moving blades has been devised. The model presupposes the existence of the isentropic 'jet' and the nonisentropic 'wake', which includes the regions of secondary flow, of separated flow as well as of boundary layers. The satisfactory agreement of experimental results with the above mentioned theoretical flow model justifies fully the simplifying assumptions. The advantage of the model is the possibility to examine in a simple way the influence of basic flow characteristics, profile losses, secondary flow effects, etc., on the resultant stage efficiency. Author

A85-41805

**FULLY-THREE DIMENSIONAL FLOW FIELD ANALYSIS THROUGH TURBINE STAGES - COMPARISON BETWEEN COMPUTATION AND EXPERIMENTS**

T. KOBAYASHI, A. SUZUKI (Toshiba Corp., Yokohama, Japan), T. ARAKI, and Y. OKAMOTO (Toshiba Corp., Research and Development Center, Kawasaki, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 353-360. refs

The flow through a transonic axial flow turbine stage with a significantly diverging flow passage has been analyzed using a three-dimensional time marching method. A reasonable numerical treatment at the flow boundary between stator and rotor is considered with a rotating coordinate system for the expression of the rotor field. Detailed measurements were carried out using an experimental air turbine, which confirmed the validity of the analysis method. Flow visualization tests clarified the predicted three-dimensional distortion of the stream surfaces within the blades. It is concluded that this calculation method is of practical use for the design of transonic axial flow turbines. Author

A85-41809

**MEASUREMENTS OF FLOW FIELD WITHIN AN AXIAL FLOW FAN ROTOR USING A LASER TWO FOCUS VELOCIMETER**

S. YASU, T. TAMAKI, and S. NAGANO (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 381-385. refs

The flow field within the rotor of a transonic axial flow fan has been investigated in the tip region by using a Laser Two Focus velocimeter. The tests were carried out at design speed and mass flow corresponding to the point of maximum efficiency. The flow phenomena investigated include the flow variation from passage to passage, the shock intensity, the three-dimensionality of the shock in the blade passage and the shock boundary layer interaction. Author

A85-41810

**SOME APPLICATIONS OF ACTUATOR AND SEMI-ACTUATOR DISK THEORY TO THE PROBLEM OF INTAKE/ENGINE COMPATIBILITY**

C. J. HAM and D. D. WILLIAMS (Rolls-Royce, Ltd., Bristol, England) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 387-398. refs

This paper discusses some of the major findings resulting from the application of actuator disk theories to the mathematical modeling of turbomachinery in distorted intake flow conditions. Particular problems addressed are those of circumferentially maldistributed total-pressure with and without intake swirl; flow interference between the compressors of a single-stream, multispool engine, and some features of backstatic distortion. The main emphasis of the paper is the stability aspect of the inlet/engine compatibility problem. Author

A85-41813

**DEVELOPMENT OF COMPUTATIONAL FLOW ANALYSIS FOR BLADE ROWS**

H. H. FRUEHAUF (Stuttgart, Universitaet, West Germany) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 415-422. refs

Progress in the development of direct two- and three-dimensional numerical methods for steady subsonic inviscid flows through plane cascades and annular cascades of compressors and turbines is presented. Cascade flows are compared, solving either the potential, Euler, or thin-layer Navier-Stokes equations by finite difference techniques. Emphasis, in this paper, is primarily on selected boundary condition implementation techniques and resolution techniques which lead to a more accurate computation of inviscid and viscous cascade flows. Computed results for both inviscid and viscous flows are compared with other existing cascade solutions and experimental data. The material presented is taken from recent investigations carried out in the turbomachinery aerodynamics group at the University of Stuttgart. Author

A85-41814\* Politecnico di Torino (Italy).

**TIME DEPENDENT COMPUTATION OF THE EULER EQUATIONS FOR DESIGNING 2-D CASCADES, INCLUDING THE CASE OF TRANSONIC SHOCK FREE DESIGN**

L. ZANNETTI (Torino, Politecnico, Turin, Italy) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 423-429. refs  
(Contract NAS3-22772)

A numerical method to solve the inverse problem for airfoil cascades is described. The case of compressible, inviscid flow is considered. The proposed method is based on the finite difference approximation of the time-dependent Euler equations. Numerical examples show the capability of the method to design subsonic or transonic shockless blades. Author

A85-41815

**A NUMERICAL METHOD TO WEAKEN SHOCK IN TRANSONIC CASCADES**

S. ZHOU (Beijing Institute of Aeronautics and Astronautics, People's Republic of China), B. Z. LIN (Chinese Academy of Space Technology, Beijing, People's Republic of China), and H. X. JIANG IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 431-438.

A numerical method to weaken shock wave in transonic cascades is presented in the paper. Numerical results for two cascades are given and discussed, which show that the effect of weakening shock is evident. The method is practical if it is incorporated into current compressor design system. Author

## 02 AERODYNAMICS

**A85-41816**

**A COMPARISON OF THE STREAMLINE CURVATURE METHOD WITH THE MATRIX METHOD USED FOR TURBO-MACHINERY DESIGN IN NON-ORTHOGONAL CURVILINEAR COORDINATE SYSTEM**

Z.-C. WANG, W.-Y. XU (Harbin Institute of Technology, People's Republic of China), and G.-I. LI (Harbin University of Science and Technology, People's Republic of China) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 439-445. refs

In this paper the advantages and limitations of the Streamline Curvature Method (SCM) and Matrix Method (MM), employed in design of turbomachinery, in nonorthogonal curvilinear coordinate system are discussed in detail. The calculated results showed that the distributions of the flow parameters along the blade height obtained by using the above-mentioned methods approximately agree with each other, so that all of these two methods are effective for three-dimensional flow in turbomachinery from point of view of profiling blades. While comparing the following aspects, such as required computer core storage, computing time and accuracy, and suitability for optimizing design, either of them has its own advantage and limitation. Therefore, it cannot be considered that one of them is absolutely superior to the other. Author

**A85-41817**

**PURELY THREE-DIMENSIONAL ANALYSIS OF A FLOW IN AN AXIAL ROTOR BY PANEL METHOD**

Y. MIYAKE, K. BANDO, T. MIYAWAKI (Osaka University, Suita, Japan), and S. MURATA (Toyota Technical Institute, Nagoya, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 447-454. refs

In this paper, purely three-dimensional, incompressible, inviscid flow analysis by means of a panel method is presented for an axial-flow fan composed of a single-stage rotor. The field equation based on Green's theorem is used as the governing equation for velocity potential  $\phi$ . The foundations to obtain the solution with acceptable accuracy are described, such as how to choose the particular solution to  $\phi$  or how to incorporate the Kutta condition. The method is applied to a rotor of free vortex flow pattern designed by referring to the carpet diagram of NACA 65-series blades. The calculated results are compared with the two-dimensional flows calculated quasi-three-dimensionally, and the alleviation of spanwise head variation is confirmed in the purely three-dimensional calculation. Other results include pressure distributions around blade elements at hub, mid-span and shroud, and pressure contours and velocity vectors on the pressure- and suction-surfaces of the blade. Author

**A85-41818**

**FINITE ELEMENT ANALYSIS FOR 3-D COMPRESSIBLE POTENTIAL FLOW IN TURBOMACHINERY**

H. DAIGUJI (Tohoku University, Sendai, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 455-462. refs

A numerical method for analyzing a 3-D steady subsonic potential flow through an impeller in axial-, mixed- and radial-flow turbomachines is presented. This method is based on the previous method for the 3-D steady incompressible potential flow proposed by the author. The main features of the method are an accurate treatment of trailing vortex sheets in the finite element calculation and a calculating procedure for the right hand side of the fundamental equation  $\text{div grad } \phi = w \cdot \text{grad } h/c\text{-squared}$ . As a numerical example the subsonic flows of a semi-axial flow blower are calculated, and velocity, Mach number and static pressure distributions are shown. Author

**A85-41819**

**TWO-DIMENSIONAL UNSTEADY FLOW IN COMPREX ROTOR**

H.-D. JIANG (Chinese Academy of Sciences, Institute of Engineering Thermophysics, Beijing, People's Republic of China) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 463-470. refs

A two-dimensional model for unsteady flow in Comprex rotor is presented. The Euler's equations which govern the compressible inviscid adiabatic unsteady flow in the meridional plane of Comprex rotor channel are solved by MacCormack difference scheme. The calculation results show clearly the entire unsteady flow history including the shock, the pressure waves, the expansion waves and their generations, propagations and reflections inside the Comprex rotor channel. All parameters of the flow field and the intersurface between two gases are discussed in detail. More attention is focused on the parameters distributions both in the axial direction and in the radial direction. The results are also compared with the experiments and with the one-dimensional calculation. Author

**A85-41820**

**THE EFFECT OF BOUNDARY LAYER CONTROL ON THE PERFORMANCE OF RADIAL FAN IMPELLERS**

A. SHIBL (King Saud University, Riyadh, Saudi Arabia) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 471-478. refs

The effect of impeller configuration on the characteristics of a fan with and without boundary layer control was investigated experimentally. Exercising such boundary layer control by wall injection over the shroud shoulder in the vaned impellers resulted in more efficient impellers (excluding the power consumed by the jet), with improved uniformity of flow pattern over the whole impeller width. The corresponding maximum power for injection was 20 percent of total power, however, the paper indicates the effectiveness of boundary layer control by injection in reducing the head loss of the impellers. Author

**A85-41824**

**RESEARCH ON SUPERSONIC DIFFUSERS OF CENTRIFUGAL COMPRESSOR BY MEANS OF SWIRL FLOW. I - FLOW IN A DIFFUSER AT VARIOUS MACH NUMBERS**

M. YAMAGUCHI and Y. SENOO (Kyushu University, Fukuoka, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 501-506.

To investigate supersonic diffusers of centrifugal compressors a test rig was built where the swirl flow was induced by inward swirl nozzles. Test diffusers demonstrated reasonably high pressure recovery coefficient even at very high Mach numbers. However, the stall limits of diffusers at positive and negative incidence angles were not clarified because it was not possible to change the flow angle in a wide range. The influence of the inlet velocity distribution on the pressure recovery of a diffuser was quite significant. Therefore, the quantitative results of a diffuser obtained in a test rig is not directly applicable to the diffuser in a different rig where distortion of the inlet velocity distribution is somewhat different. However, the present test rig is suitable to compare the performances of different diffusers which are designed for the same application and to choose the best design. Also presented are many problems which have to be overcome to make a test rig for supersonic diffusers of centrifugal compressors. Author

A85-41825

**AERODYNAMIC PERFORMANCE OF A TURBINE SCROLL WITH A DIAGONAL FLOW NOZZLE**

T. IKUI, M. INOUE, K. HARA, and M. FURUKAWA (Kyushu University, Fukuoka, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 507-514. refs

In order to clarify the internal flow characteristics of a vaneless scroll nozzle for a diagonal flow gas turbine, an experimental investigation was carried out with a variable geometry scroll which has a movable side wall. The effects of the scroll passage height and the space between the scroll tongue and the hub were examined. In particular, it was found that the secondary flow strongly affects the scroll nozzle performance and the peripheral nonuniformity of the flow is caused by the wall boundary layer accumulating between the tongue and the hub. Author

A85-41826\* Cincinnati Univ., Ohio.

**THE THREE-DIMENSIONAL COMPRESSIBLE FLOW IN A RADIAL INFLOW TURBINE SCROLL**

A. HAMED, W. TABAKOFF, and M. MALAK (Cincinnati, University, OH) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 515-521. refs

(Contract NAG3-52; NAG3-26)

This work presents the results of an analytical study and an experimental investigation of the three-dimensional flow in a turbine scroll. The finite element method is used in the iterative numerical solution of the locally linearized governing equations for the three-dimensional velocity potential field. The results of the numerical computations are compared with the experimental measurements in the scroll cross sections, which were obtained using laser Doppler velocimetry and hot wire techniques. The results of the computations show a variation in the flow conditions around the rotor periphery which was found to depend on the scroll geometry. Author

A85-41827

**MEASUREMENT OF THE THREE-DIMENSIONAL UNSTEADY FLOW INSIDE A ROTOR BLADE PASSAGE OF AN AXIAL-FLOW FAN**

K. MATSUUCHI and T. ADACHI (Tsukuba, University, Sakura, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 523-530. refs

The flowfield inside a rotor blade passage in an axial-flow fan is very complicated because of its three-dimensionality and unsteadiness. Measurement for a periodic-average flowfield was made with a single hot-wire probe rotating with the rotor in order to obtain a better understanding of the fluid physics involved. The characteristics of the wake of upstream stator and the three-dimensional structure of the flow within the rotor passage were investigated. Author

A85-41828

**MEASUREMENT OF 3-D UNSTEADY FLOW DOWNSTREAM OF ROTOR AND STATOR BLADES IN AXIAL-FLOW COMPRESSORS**

H. E. GALLUS and H. HOENEN (Aachen, Rheinisch-Westfaelische Technische Hochschule, West Germany) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 531-538. refs

The reported program of measurements aimed at the investigation of the unsteady viscous flow-field between hub and tip in a subsonic axial-flow compressor stage. Beside blade pressure distributions the wake-flow was measured downstream of rotor and stator blades. The degree of turbulence within the wakes could be determined by hotwire-technique along the radius. The experimental results will be demonstrated and discussed with respect to consequences for compressor aerodynamics and dynamic blade-loads. Author

A85-41834

**MEASUREMENT OF THE RADIAL FLOW ALONG A LOW SPEED COMPRESSOR BLADING DURING UNSTALLED AND STALLED OPERATION**

F. A. E. BREUGELMANS, L. LAMBROPOULOS, and K. MATHIOUDAKIS (Institut von Karman de Dynamique des Fluides, Rhode-Saint-Genese, Belgium) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 613-620. refs

A single stage low speed axial flow compressor is used to investigate the radial drift along the rotor blade during unstalled and stalled operation. V-shaped hot wire sensors are installed at 0.4 mm from the blade surface on three chordwise locations. The hot wire signals are digitized and processed using a fast Fourier transform and the phase locked averaging technique. A radial drift along the suction surface is observed in the unstalled region. The occurrence of rotating stall causes a large inward motion in the front part of the channel (-30 deg) and a radially outward drift of +60 deg at the 50 percent chord position. The combination of these observations in the relative motion and the absolute measurements suggest that there exist a large recirculation in the rotating blades. Author

A85-41835

**AERODYNAMIC RESPONSES OF TURBINE ROTOR BLADE TO SINUSOIDAL GUST OF LARGE VORTICITY**

T. NISHIYAMA and K. FUNAZAKI (Tohoku University, Sendai, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 643-649. refs

A method of singularity is developed for the analysis of aerodynamic responses of turbine rotor blade to sinusoidal gust of large vorticity. It is shown that the upstream gust suffers a significant distortion within the passage of finite-loaded cascade because of the conservation law of vorticity, which has been taken into account in the analysis. The numerical results reveal some notable influences of finite steady loading and higher order harmonics in the gust on the unsteady pressure, fluid forces and wake vortex energy of turbine rotor blade. Author

A85-41837

**AERODYNAMIC CHARACTERISTICS OF AN AIRFOIL OSCILLATING IN TRANSONIC FLOW BETWEEN PARALLEL WALLS**

T. SHIRATORI (Metropolitan College of Technology, Tokyo, Japan) and Y. TANIDA (Tokyo, University, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 659-666. refs

Aerodynamic characteristics of an airfoil oscillating in the transonic flow between parallel walls was investigated by numerical analysis using a finite-difference method. Shock wave movement due to the oscillation of airfoil, aerodynamic instability of airfoil and the relations between them were investigated for several cases. The results obtained show that, in pitching oscillation mode, the shock wave movement is a dominant factor in aerodynamic instability, which acts as a positive damping in low reduced frequency, and acts as a main negative damping in high reduced frequency. In two-degree-of-freedom oscillation, airfoil becomes unstable depending on the phase-difference between these two modes, e.g., a classical type flutter exists in transonic flow between parallel walls. Further, the results obtained for the cases of pitching oscillation were compared with the experimental results. Both results were in good qualitative agreement. Author

## 02 AERODYNAMICS

A85-42040

### LARGE-ANGLE CONE-SHAPED BODIES IN SUPERSONIC THREE-DIMENSIONAL STREAM

P. I. CHUSHKIN (AN SSSR, Vychislitel'nyi Tsentr, Moscow, USSR) (Symposium on Advanced Problems and Methods in Fluid Mechanics, 16th, Spala, Poland, Sept. 4-10, 1983) *Archiwum Mechaniki Stosowanej* (ISSN 0373-2029), vol. 36, no. 2, 1984, p. 219-232. refs

A numerical investigation of the three-dimensional flow about large-angle cone-shaped bodies at an angle of attack in a supersonic free stream of gas is carried out. The bodies have a finite length, a small bluntness at the apex, and an angle exceeding the limiting one. The mixed flow behind the detached shock wave is calculated by the method of integral relations using special variables which are consistent with the flow behavior near the body apex. The influence of the free-stream parameters and the body geometry is studied. Both cones and cone-shaped concave noses are considered. Author

A85-42119

### ESTIMATION OF THE WAVE RESISTANCE OF BODIES OF REVOLUTION WITH A FRONT SEPARATION ZONE IN SUPERSONIC FLOW [OTSENKA VOLNOVOGO SOPROTVLENIIA TEL VRASHCHENIIA S PEREDNEI SRYVNOI ZONOI V SVERKHZRUKOVOM POTOKE]

I. A. BELOV, S. A. ISAEV, A. I. MITIN, and V. N. KONOVALOV (Leningradskii Mekhanicheskii Institut, Leningrad, USSR) *Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seria Tekhnicheskii Nauki* (ISSN 0002-3434), March 1985, p. 47-51. In Russian. refs

An approximate method for estimating the coefficient of wave resistance of a cylindrical body with a disc nozzle in its front part is proposed which uses the results of a numerical solution to the Euler equation obtained by Godunov's finite difference scheme. A comparison of the calculated and experimental data indicates that the approach proposed here is valid for high Reynolds numbers. The applicability limits of the method are determined from the characteristic geometrical dimensions of the body. V.L.

A85-42120

### NONSTATIONARY AERODYNAMIC CHARACTERISTICS OF A PROFILE IN SEPARATED FLOW NEAR AN UNDATED WALL [NESTATSIONARNYE AERODINAMICHESKIE KHKARAKTERISTIKI PROFILIA PRI OTRYVNOB OBTEKANII VBLIZI VOLNISTOI STENKI]

L. V. MIKHAILOVA and G. M. SHUMSKII (Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seria Tekhnicheskii Nauki (ISSN 0002-3434), March 1985, p. 56-60. In Russian. refs

The problem of a nonstationary separated flow of an ideal incompressible fluid past a thin profile moving in the vicinity of an undulated wall is investigated analytically, with the profile and the wall modeled by a system of vortex singularities. The vortex wake behind the profile is reconstructed in the process of solving the problem. The analysis reveals the hysteresis nature of the dependence of the aerodynamic characteristics of the profile of the kinetic parameters. V.L.

A85-42123

### STABILITY CHARACTERISTICS OF A SUPERSONIC BOUNDARY LAYER AND THEIR RELATION TO THE POSITION OF THE LAMINAR-TURBULENT TRANSITION POINT [KHKARAKTERISTIKI USTOICHIVOSTI SVERKHZVUKOVOGO POGRANICHNOGO SLOIA I IKH SVIAZ' S POLOZHENIEM PEREKHODA LAMINARNOGO POGRANICHNOGO SLOIA V TURBULENTNYI]

V. I. LYSENKO (AN SSSR, Institut Teoreticheskoi i Prikladnoi Mekhaniki, Novosibirsk, USSR) *Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seria Tekhnicheskii Nauki* (ISSN 0002-3434), March 1985, p. 79-86. In Russian. refs

By comparing the calculated results with experimental data, it is demonstrated that the position of the laminar-boundary transition point of a boundary layer can be estimated by using the e-exp-n method. The effect of the Mach number, pressure gradient, and

heat transfer on the laminar-turbulent transition is discussed. It is found that under conditions of strong cooling, the effect of the pressure gradient on the position of the transition point is less pronounced than in the absence of heat transfer. V.L.

A85-42287

### THE IDEAL-LIQUID CONCEPT IN CALCULATIONS ON THE DETACHED FLOW AROUND BLUNT OBJECTS WITH A TURBULENT SHEAR LAYER AT THE BOUNDARY OF THE DETACHMENT REGION

I. A. BELOV, S. A. ISAEV, A. I. MITIN, and V. N. KONOVALOV (Leningradskii Mekhanicheskii Institut, Leningrad, USSR) (*Pis'ma v Zhurnal Tekhnicheskoi Fiziki*, vol. 10, Oct. 26, 1984, p. 1217-1220) *Soviet Technical Physics Letters* (ISSN 0360-120X), vol. 10, Oct. 1984, p. 514, 515. Translation. refs

The results of numerical and experimental examinations of an axisymmetric flow around a cylinder downstream from a disk in a supersonic flow are reported. The flow Mach number was 4.15 and the Re was 1.6 million. The study focused on viscous effects and the usefulness of turbulent and artificial diffusion in a Godunov formulation for the problem. Data and calculations of the wave drag coefficients were compared. Discrepancies in the values confirmed the deficiency in using both artificial and turbulent diffusion mechanisms in the model. Once account was taken of turbulent flow in the shear layer, good agreement was found. M.S.K.

A85-42351#

### AN EXPERIMENTAL INVESTIGATION OF AN AIRFOIL UNDERGOING LARGE-AMPLITUDE PITCHING MOTIONS

J. M. WALKER, H. E. HELIN, and J. H. STRICKLAND (U.S. Air Force Academy, Colorado Springs, CO) *AIAA Journal* (ISSN 0001-1452), vol. 23, Aug. 1985, p. 1141, 1142. Abridged. Previously cited in issue 07, p. 835, Accession no. A85-19474. (Contract F49620-82-C-0035)

A85-42352# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### COMPUTATION OF THE TIP VORTEX OFF A LOW-ASPECT-RATIO WING

N. N. MANSOUR (NASA, Ames Research Center, Moffett Field; Stanford University, CA) *AIAA Journal* (ISSN 0001-1452), vol. 23, Aug. 1985, p. 1143-1149. Previously cited in issue 06, p. 712, Accession no. A84-18149. refs (Contract NAG2-029)

A85-42353# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### HIGH ANGLE-OF-ATTACK CALCULATIONS OF THE SUBSONIC VORTEX FLOW ON SLENDER BODIES

D. ALMOSNINO (NASA, Ames Research Center, Moffett Field, CA) *AIAA Journal* (ISSN 0001-1452), vol. 23, Aug. 1985, p. 1150-1156. Previously cited in issue 05, p. 578, Accession no. A83-16475. refs

A85-42441#

### A DISCUSSION ON LIFT AND MOMENT CHARACTERISTICS OF AEROFOILS IN INCOMPRESSIBLE POTENTIAL FLOWS

C. LIN (Northwestern Polytechnical University, Journal, vol. 3, April 1985, p. 201-205. In Chinese, with abstract in English.

A new method of verifying the lift and moment characteristics of airfoils in incompressible potential flows which is unrelated to conformal mapping and is applicable to multiple-section airfoils as well as single section ones is presented. The key idea of this new method is that the complex potential can be expressed by a certain linear combination. The lift and moment of the airfoil are then evaluated by Blasius' formulas in the usual way. It is shown that the characteristics of single-section airfoils also hold for multiple-section ones. C.D.

A85-42673#

**NUMERICAL COMPUTATION OF HYPERSONIC LAMINAR NEAR-WAKE FLOW VIA NAVIER-STOKES SOLVER**

Y. TASSA and R. J. CONTI (Lockheed Research Laboratories, Palo Alto, CA) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 15 p. refs

(Contract N00014-82-C-0690)

(AIAA PAPER 85-1672)

Numerical solutions of the Navier-Stokes equations are obtained for laminar hypersonic near-wake flow behind cones at zero angle of attack. Numerical simulations are presented for a cone with a 7-degree half-angle. The study includes three values of free-stream Mach number (4.32, 6.32, 10.0) and four values of Reynolds number ranging from 21,500 to 172,000 referenced to base diameter. The numerical scheme is patterned after the Alternating Direction Implicit method of Beam and Warming, with modification to include finite-volume discretization and spatially variable time step for accelerating convergence to steady state. Comparisons are made with experimental data for base pressure, length of the recirculating region, and general flow-field structure. Effects of Mach and Reynolds numbers on the laminar near-wake flowfield structure are reported.

Author

A85-42690\*# PEDA Corp., Palo Alto, Calif.

**FLOW STRUCTURE CAPTURING ON OVERSET PATCHED MESHES**

E. VENKATAPATHY and C. K. LOMBARD (PEDA Corp., Palo Alto, CA) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 13 p. refs

(Contract NAS2-11920; F49620-83-C-0084)

(AIAA PAPER 85-1690)

The present paper describes the application of a simple, robust stable implicit approach to solutions of the conservative equations of gasdynamics on either composite or overset meshes to capture flow structures such as shocks with high resolution in complex geometric domains. Without requiring special flux conservative operators, but rather, interpolating conservative variable data at mesh boundaries, the well posed upwind method provides accurate and oscillation free solutions, even when shocks cross the interior patch boundaries. In three problems with flow complexities that require grid refinement, the paper demonstrates the capability to conveniently carry out for gasdynamics the adaptive refined meshing strategy in overset patches proposed by Berger and Olinger (1984), and it extends this technique to rapidly convergent implicit methods for the Euler and Navier-Stokes equations. The numerical experiments show concretely, in a realistic aerodynamic problem, the savings in mesh points (about an order of magnitude here in two dimensions) for similar accuracy that flow structure aligned adaptive patched meshing affords compared to uniform grid refinement.

Author

A85-42783#

**TRANSITION EFFECTS OF BOUNDARY LAYER ON STATIC AND DYNAMIC STABILITY OF SLENDER CONE**

H. LOU Chinese Society of Astronautics, Journal, no. 1, 1985, p. 88-98. In Chinese, with abstract in English. refs

This paper presents the experimental technique of transition effects of boundary layer on static and dynamic stability of a slender cone and analyzes its result. The experimental result shows that the effects of Re number on static and dynamic stability of slender cone are very important. The variation of Re number induces a change in the position of the natural transition of the boundary layer in the cone face; thus, the induced moment and the induced damping moment of the transition are changed. When the transition exists on the surface of the afterbody of the cone, there is a great increase in dynamic stability and a great decrease in static stability; on the other hand, when the transition occurs forward of the center of gravity, there is some decrease in dynamic stability and some increase in static stability.

Author

A85-42913\*# National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

**ENGINEERING FLOWFIELD METHOD WITH ANGLE-OF-ATTACK APPLICATIONS**

E. V. ZOBY and A. L. SIMMONDS (NASA, Langley Research Center, Hampton, VA) Journal of Spacecraft and Rockets (ISSN 0022-4650), vol. 22, July-Aug. 1985, p. 398-404. Previously cited in issue 06, p. 708, Accession no. A84-18010. refs

A85-42926#

**VORTEX TRAJECTORIES AND BREAKDOWN ON WING-CANARD CONFIGURATIONS**

J. ER-EL and A. SEGNER (Technion - Israel Institute of Technology, Haifa) Journal of Aircraft (ISSN 0021-8669), vol. 22, Aug. 1985, p. 641-648. Previously cited in issue 17, p. 2455, Accession no. A83-38649. refs

A85-42927#

**PROPELLER AERODYNAMIC PERFORMANCE BY VORTEX-LATTICE METHOD**

M. KOBAYAKAWA (Kyoto University, Japan) and H. ONUMA Journal of Aircraft (ISSN 0021-8669), vol. 22, Aug. 1985, p. 649-654. refs

It is inappropriate to apply classical propeller theories to design an advanced turboprop (ATP). In this paper, the vortex-lattice method is applied to rotating blades. It is assumed that the flow is inviscid and incompressible. However, the compressibility effect is included in the calculations through the Prandtl-Glauert similarity rule. The other properties characteristics of an ATP, i.e., the effect of displacement velocities, the interference effect between blades, and the effect of flow deflection by a spinner and nacelle, are introduced into the calculations. Powers, thrusts, and efficiencies of two kinds of ATP, SR-1 and SR-3, are obtained and compared with experimental values. The numerical values show that they agree well with the experimental results of SR-1. However, the former is larger than those of SR-3. This is consistent with the calculations by Hamilton Standard. The principal reason for this difference is that the portion of the blade near the tip is distorted by centrifugal force. Using this method, the ATP performance can be calculated accurately below Mach 0.6. However, the transonic wing theory should be applied for performance estimates at Mach 0.7-0.8.

Author

A85-42928#

**ITERATIVE THREE-DIMENSIONAL TRANSONIC WING DESIGN USING INTEGRAL EQUATIONS**

S. TAKANASHI (National Aerospace Laboratory, Tokyo, Japan) Journal of Aircraft (ISSN 0021-8669), vol. 22, Aug. 1985, p. 655-660. Previously cited in issue 20, p. 2844, Accession no. A84-41332. refs

A85-42929#

**TRANSIENT AERODYNAMIC CHARACTERISTICS OF A TWO-DIMENSIONAL AIRFOIL DURING STEPWISE INCIDENCE VARIATION**

Y. AIHARA, H. KOYAMA (Tokyo, University, Japan), and A. MURASHIGE Journal of Aircraft (ISSN 0021-8669), vol. 22, Aug. 1985, p. 661-668. Previously cited in issue 20, p. 2847, Accession no. A84-42332. refs

A85-42931#

**TRANSONIC AERODYNAMIC COMPUTATIONS FOR A CANARD CONFIGURATION**

N. AGRELL (Flygtekniska Forsoksanstalten, Bromma, Sweden) and L. ELMELAND (Saab-Scania AB, Linkoping, Sweden) Journal of Aircraft (ISSN 0021-8669), vol. 22, Aug. 1985, p. 675-678. Sponsorship: Defence Materiel Administration of Sweden. Previously cited in issue 20, p. 2844, Accession no. A84-41333. refs

(Contract DMA-AU-1691)



## 02 AERODYNAMICS

**A85-42951\***

**SYMPOSIUM ON NUMERICAL AND PHYSICAL ASPECTS OF AERODYNAMIC FLOWS, 3RD, CALIFORNIA STATE UNIVERSITY, LONG BEACH, CA, JANUARY 21-24, 1985, PROCEEDINGS**

Symposium supported by NSF, U.S. Navy, U.S. Army, and NASA. Long Beach, CA, California State University, 1985, 546 p. For individual items see A85-42952 to A85-42992.

Among the topics discussed are hydrodynamic stability and turbulent transition, separated flow simulations employing finite difference methods, a quasi-simultaneous finite difference approach for strongly interacting flow, the Newton solution of coupled Euler and boundary layer equations, multielement airfoil aerodynamics, vorticity dynamics, the significance of the thin layer Navier-Stokes approximation, a comparison of interactive and Navier-Stokes calculations of separating boundary layer flows, and a Navier-Stokes analysis for the mechanism of shock wave/boundary layer interactions. Also discussed are transonic interactions of unsteady vortical flows, boundary layers on oscillating airfoils, a laser-interferometer skin friction meter, flow over surface-mounted semibluff bodies, computations for spinning and spin-stabilized supersonic projectiles, transition calculations in three-dimensional flows, the effect of projectile boattailing in transonic flow, flow characteristics of a body of revolution at incidence, the influence of the boundary layer on the leading edge flow of a swept wing, and an interactive scheme for three-dimensional transonic flows.

O.C.

**A85-42953\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**DEVELOPMENTS IN THE SIMULATION OF SEPARATED FLOWS USING FINITE DIFFERENCE METHODS**

J. L. STEGER and W. R. VAN DALSEM (NASA, Ames Research Center, Moffett Field, CA) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 1-1 to 1-20. refs

Compressible viscous flow simulation using finite difference Navier-Stokes and viscous-inviscid interaction methods is described. Recent developments are reviewed that significantly improve the computational efficiency of approximately factored implicit Navier-Stokes algorithms. Compared to Navier-Stokes codes, modern viscous-inviscid interaction codes are more computationally efficient, but have restricted application and are more complicated to program. Therefore, less efficient but more general viscous-inviscid interaction methods are investigated that use forcing functions instead of boundary condition matching, and a simple, direct/inverse, three-dimensional, finite-difference, boundary layer code is presented.

Author

**A85-42954\*#** Grumman Aerospace Corp., Bethpage, N.Y.

**THE COMPUTATION OF VISCID/INVISCID INTERACTION ON AIRFOILS WITH SEPARATED FLOW**

R. E. MELNIK and J. W. BROOK (Grumman Research and Development Center, Bethpage, NY) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 1-21 to 1-37. Research supported by the Grumman Aerospace Independent Research and Development Program. refs

Attention is given to the computation of viscous subsonic and transonic flow over two-dimensional airfoils at high Reynolds numbers, where the boundary layers are thin and turbulent over most of the airfoil and its wake. An attempt is made to develop a fast viscid/inviscid interaction method for the computation of viscous flows over airfoils with extensive low separation regions, which can be used as the basis of predictions of the stalling characteristics of airfoils with reasonable accuracy. These insights are applied in the form of changes to the GRUMFOIL computer code, in order to improve separated flow prediction capabilities.

O.C.

**A85-42955#**

**LAMINAR SEPARATION STUDIED AS AN AIRFOIL PROBLEM**

H. K. CHENG and C. J. LEE (Southern California, University, Los Angeles, CA) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 1-39 to 1-61. refs

(Contract N00014-82-K-0315)

A global model of boundary layer breakaway, in which the triple-deck description is an essential element, has been applied to the study of laminar separation from airfoils by Cheng and Smith (1982) and Cheng (1984). This paper presents a more extensive study of those interaction problems which give rise to bifurcating solutions of the steady-state flows, and to symmetry breaking and lift hysteresis in particular. The study also clarifies the role of the eddy pressure and the need for a second separation downstream of a laminar bubble. Results agree qualitatively with the lift anomalies observed experimentally for symmetric NACA four-digit sections at  $Re = 10,000-100,000$ .

Author

**A85-42956#**

**A QUASI-SIMULTANEOUS FINITE DIFFERENCE APPROACH FOR STRONGLY INTERACTING FLOW**

D. E. EDWARDS and J. E. CARTER (United Technologies Research Center, East Hartford, CT) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 1-63 to 1-73. refs

(Contract N00014-81-C-0381)

An Interacting Boundary-Layer Theory (IBLT) method which employs a quasi-simultaneous technique to couple the finite difference representations of the inviscid and viscous flow equations has been developed for the analysis of strongly interacting flows. This quasi-simultaneous coupling technique is a generalization of the work of Veldman, Davis, Moses, and Wai and Yoshihara. In this paper, a study is made of the convergent rate of an analysis using this new coupling technique in comparison with that obtained using Carter's semi-inverse technique by performing computations of several laminar incompressible separated flows. A major conclusion of this paper is that the IBLT method using the quasi-simultaneous coupling technique converges at a faster rate than the semi-inverse coupling procedure as the size of the separated flow region increases.

Author

**A85-42957\*#** Iowa State Univ. of Science and Technology, Ames.

**APPLICATION OF A VISCOUS-INVISCID INTERACTION METHOD TO PREDICT TRANSONIC SEPARATED FLOWS**

D. S. LEE and R. H. PLETCHER (Iowa State University of Science and Technology, Ames, IA) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 1-75 to 1-85. refs

(Contract NAG2-152)

A viscous-inviscid interaction numerical procedure is used to predict turbulent transonic separated flows over axisymmetric bodies. The viscous flow solutions are obtained by solving the boundary-layer equations inversely in a coupled manner by a finite-difference scheme; the inviscid flow is determined by a finite-difference solution to the full-potential equation in conservative form. Parameters affecting the convergence rate of the interaction procedure are discussed. The predictions of a new turbulence model proposed by Johnson and King are compared with experimental data and numerical solutions to the Navier-Stokes equations for flows with large regions of separation.

Author

A85-42958#

**NEWTON SOLUTION OF COUPLED EULER AND BOUNDARY LAYER EQUATIONS**

M. DRELA, M. GILES, and W. T. THOMPSON, JR. (MIT, Cambridge, MA) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 2-1 to 2-8. refs  
(Contract F49620-78-C-0084)

A method is presented for the rapid and robust solution of strongly coupled viscous-inviscid flow interactions. The inviscid solver is a Newton solution of a finite volume formulation of the Euler equations. The viscous solver is a compressible laminar/turbulent integral method. Unlike coupling schemes which iterate between the inviscid and viscous solvers, the method presented here incorporates the viscous solver directly into the Newton solver, such that both the inviscid and viscous linearizations are solved simultaneously. Results are presented for: (1) a high work turbine cascade with a transitioning separation bubble on the pressure surface, (2) the RAE 2822 transonic airfoil with a shock-boundary layer interaction, and (3) the NLR 7301 supercritical airfoil.

Author

A85-42959#

**AIRFOILS WITH SEPARATION AND THE RESULTING WAKES**

T. CEBECI (California State University, Long Beach), R. W. CLARK, K. C. CHANG, N. D. HALSEY (Douglas Aircraft Co., Long Beach, CA), and K. LEE IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 2-13 to 2-25. refs  
(Contract NSF MEA-80-18565)

A viscous/inviscid interaction method is described and has been used to calculate flows around three distinctly different airfoils as a function of angle of attack. It comprises an inviscid flow method based on conformal mapping, a boundary-layer procedure based on the numerical solution of differential equations and an algebraic eddy viscosity. The results are in close agreement with experiment up to angles close to stall. In one case, where the airfoil thickness is large, small difficulties were experienced and are described. The method is shown to be capable of obtaining results with large flow separation and quantifies the role of transition on the lift coefficient.

Author

A85-42960#

**RESEARCH INTO MULTI-ELEMENT AEROFOIL AERODYNAMICS**

D. J. BUTTER (British Aerospace, PLC, Stockport, England) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 2-27 to 2-34.

Knowledge of the fundamental physics of the flow around even two-dimensional multielement airfoils is difficult to advance by means of the ad hoc testing associated with project design. In three dimensions, significant improvements are anticipated from the optimization of the spanwise grading of the slat and flap gaps, overlaps, chords and section shapes, inboard wing design refinements, the minimization of flap-end interference effects, and design-to-flight-Reynolds number. A comprehensive theoretical method is needed which will predict changes due to the alteration of such parameters as maximum lift and design condition lift/drag value. Until that theoretical tool is available, extensive experimental support will be required.

O.C.

A85-42961#

**VORTICITY DYNAMICS - A VISCOUS POINT OF VIEW OVER AERODYNAMICS**

J. C. WU (Georgia Institute of Technology, Atlanta) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 3-1 to 3-11. refs  
(Contract AF-AFOSR-82-0108)

Principles of vorticity dynamics are formulated and employed in theoretical and computational studies of various aerodynamic problems. A general theory of aerodynamics is derived rigorously on the basis of the Navier-Stokes equations without the inviscid fluid assumption. The theory expresses the aerodynamic load acting on a lifting body in terms of the vortical environment of the body. The theory permits the contributions of various flow elements present in viscous flows, including flows with massive separated regions, to be identified and evaluated separately. This distinguishing ability of the theory has been utilized to establish a much improved understanding of the physical processes involved in the generation of aerodynamic forces. Several problems of practical interest have been studied comprehensively using this theory. A special computational method has been developed, calibrated and utilized also in the study of these problems. The method allows the computation field to be confined to the vortical (viscous) part of the flowfield. That is, no computation is required in the potential part of the flow. Furthermore, in cases involving massive flow separation, the attached boundary layers and the detached recirculating and wake zones can be separately computed. This computational method is based on the principles of vorticity dynamics and is ideally-suited for high Reynolds number viscous flow computations.

Author

A85-42963#

**FINITE ANALYTIC PREDICTION OF TURBULENT FLOW PAST AN INCLINED CYLINDER**

C. J. CHEN and W. S. CHENG (Iowa, University, Iowa City) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 3-27 to 3-41. refs  
(Contract N00014-84-K-0068)

In this paper, the finite analytic method which utilizes the local analytic solution of the partial differential equation is used to predict three-dimensional turbulent flow past an inclined cylinder. The turbulence model considered is a two-scale k-epsilon turbulence model which utilizes one large scale for an energy-containing eddy and one small scale for an energy-dissipating eddy in modeling the second-order correlation. Prediction of turbulent flow are made for all three components of velocity and pressure distribution. Solutions are obtained for Reynolds number of 3.7 million, while the angles of attack with respect to the cylindrical axis are 5, 10 and 15 degrees. The development of turbulent boundary layer and pressure on the inclined cylinder are predicted. The applications to engineering design are also discussed. It is found that the finite analytic method, together with two-scale k-epsilon turbulence model, predicts satisfactory results.

Author

**A85-42964\*# MISSISSIPPI STATE UNIV., MISSISSIPPI STATE. VISCOUS-INVISCID INTERACTION COMPUTATIONS USING A PSEUDO NAVIER-STOKES APPROACH**

D. L. WHITFIELD (Mississippi State University, Mississippi State) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 4-1 to 4-6. refs  
(Contract NAG1-226)

A new method is presented for the computation of viscous-inviscid interaction. The idea is to treat rotational inviscid flow (of which flows are almost entirely composed) in a thorough manner, and accept an approximation treatment of vorticity as introduced by viscous effects. The approach is to numerically solve the Navier-Stokes equations with the viscous terms determined from an inverse boundary-layer solution. The method falls

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somewhere between a Navier-Stokes approach and an Euler and boundary-layer equation coupling approach; consequently, it is referred to as a pseudo Navier-Stokes approach. Results from both the Navier-Stokes equations and the pseudo Navier-Stokes approach are presented. Author

**A85-42965#**

### **COMPARISON OF INTERACTIVE AND NAVIER STOKES CALCULATIONS OF SEPARATING BOUNDARY LAYER FLOWS**

D. ADAIR, J. H. WHITELAW (Imperial College of Science and Technology, London, England), B. E. THOMPSON (Imperial College of Science and Technology, London, England; Waterloo, University, Canada), and B. R. WILLIAMS (Imperial College of Science and Technology, London; Royal Aircraft Establishment, Farnborough, England) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 4-7 to 4-14. Research supported by the Ministry of Defence (Procurement Executive), Department of Education of the Northern Ireland, and SERC. refs

Three flows are used as a basis for an evaluation of two calculation procedures. The flows show trailing edge, upper-surface separation and the calculations extend from upstream of this separation into the downstream wake. The first calculation method was based on the interaction of solutions of potential flow equations with those of an integral form of the boundary-layer equation. The second involved solutions of a two-dimensional, time-averaged form of the Navier-Stokes equations, with a finite-difference grid generated from solutions of the potential flow equations obtained by the same numerical technique. The results show that both methods are in reasonable accord with measurement but with quantitative differences which imply need for improvement. The interactive procedure requires extension to include the effects of cross-stream pressure gradients and the Navier-Stokes technique needs improvement to reduce numerical inaccuracies. Author

**A85-42966#**

### **DEVELOPMENT OF A NAVIER-STOKES ANALYSIS TO INVESTIGATE THE MECHANISM OF SHOCK/WAVE BOUNDARY LAYER INTERACTIONS**

D. V. ROSCOE, H. J. GIBELING, H. McDONALD, and S. J. SHAMROTH (Scientific Research Associates, Inc., Glastonbury, CT) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 4-15 to 4-23. refs  
(Contract DAAG29-80-C-0082)

**A85-42967#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### **FINITE-VOLUME SCHEME FOR TRANSONIC POTENTIAL FLOW ABOUT AIRFOILS AND BODIES IN AN ARBITRARILY-SHAPED CHANNEL**

J. C. SOUTH, JR., L. L. GREEN (NASA, Langley Research Center, Hampton, VA), and M. L. DORIA (Valparaiso University, IN) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 4-25 to 4-33. refs

A conservative finite-volume difference scheme is developed for the potential equation to solve transonic flow about airfoils and bodies in an arbitrary channel. The scheme employs a mesh which is a nearly-conformal 'O' mesh about the airfoil and nearly orthogonal at the channel walls. The mesh extends to infinity upstream and downstream, where the mapping is singular. Special procedures are required to treat the singularities at infinity, including computation of the metrics near those points. Channels with exit areas different from inlet areas are solved; a body with a sting mount is an example of such a case. Author

**A85-42968\*#** North Carolina State Univ., Raleigh.

### **ASSESSMENT OF WIND TUNNEL CORRECTIONS FOR MULTIELEMENT AIRFOILS AT TRANSONIC SPEEDS**

R. L. GAFFNEY, JR., H. A. HASSAN (North Carolina State University, Raleigh), and M. D. SALAS (NASA, Langley Research Center, Hampton, VA) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 4-35 to 4-41. refs  
(Contract NCC1-22)

A finite volume formulation of the Euler equations using Cartesian grids is used to calculate the transonic flow over multielement airfoils and to use the resulting solutions to assess wall interference effects in wind tunnels. Available methods and recommendations for evaluating such effects, which are based on shifts in Mach number and angle of attack, are examined and the results are compared with measurements using the flapped supercritical SKF 1.1 airfoil. Based on the calculations, it is concluded that shifts in Mach number and angle of attack cannot by themselves account for viscous and wall effects on multielement airfoils at transonic speeds. Author

**A85-42969\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### **TRANSONIC INTERACTIONS OF UNSTEADY VORTICAL FLOWS**

W. J. MCCROSKEY (NASA, Ames Research Center, U.S. Army, Aeromechanics Laboratory, Moffett Field, CA) and G. R. SRINIVASAN (JAI Associates, Mountain View, CA) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 5-1 to 5-13. Previously announced in STAR as N85-21113. refs

Unsteady interactions of strong concentrated vortices, distributed gusts, and sharp-edged gusts with stationary airfoils were analyzed in two-dimensional transonic flow. A simple and efficient method for introducing such vortical disturbances was implemented in numerical codes that range from inviscid transonic small disturbance to thin-layer Navier-Stokes. The numerical results demonstrate the large distortions in the overall flow field and in the surface air loads that are produced by various vortical interactions. The results of the different codes are in excellent qualitative agreement, but, as might be expected, the transonic small-disturbance calculations are deficient in the important region near the leading edge. M.G.

**A85-42970#**

### **NUMERICAL SOLUTION OF UNSTEADY TWO-DIMENSIONAL VISCOUS FLOW AROUND BODIES**

Y. LECOINTE and J. PIQUET (Ecole Nationale Supérieure de Mécanique, Nantes, France) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 5-15 to 5-27. refs  
(Contract DRET-83-473)

The unsteady two-dimensional Navier-Stokes equations written in their vorticity-stream function formulation are solved numerically, by means of compact schemes for several geometries (circular cylinders and airfoils). Besides a detailed study of superimposed motions of a circular cylinder or a NACA 0012 airfoil immersed in a steady laminar stream, the work is concerned with the vectorization of the code and with the discussion of difficulties associated with the implementation of: (1) a mesh generation, and (2) a turbulent model. Author

A85-42971#

**OSCILLATING OBLIQUE SHOCK INTERACTION WITH A LAMINAR BOUNDARY LAYER**

L. WEI (Chinese Aeronautical Establishment, People's Republic of China) and G. R. INGER (West Virginia University, Morgantown) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 5-29 to 5-38. refs

Two typical oscillating oblique shock wave interactions (fore-aft and in pitch) with a laminar boundary layer are studied by means of the leading high Reynolds number asymptotic approximation of unsteady triple-deck theory. Analytical solutions are given for weak incident shocks and small-to-moderate reduced frequencies. By expanding the solutions in terms of reduced frequency, the low frequency behavior of the displacement thickness, upstream wall pressure and wall shear stress are obtained for both amplitude and phase-dependence on Strouhal number. Several interesting differences between the frequency response of fore-aft versus pitch oscillation interactions are illuminated by these solutions.

Author

A85-42972#

**UNSTEADY AIRFOIL BOUNDARY LAYERS - EXPERIMENT AND COMPUTATION**

P. F. LORBER and E. E. COVERT (MIT, Cambridge, MA) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 5-39 to 5-47. refs

(Contract AF-AFOSR-80-0287)

Experimental measurements and numerical computations of an unsteady turbulent boundary layer are presented. The boundary layer developed on a NACA - 0012 airfoil that was perturbed by an elliptic rotating at reduced frequencies between 0.5 and 6.4. The computations were made using the Keller's Box method to solve the unsteady boundary layer equations. An algebraic eddy viscosity turbulence model was used. The agreement between experiment and computation was satisfactory for sufficiently low values of reduced frequency and adverse pressure gradient, but became increasingly poor outside of these limits. Suggestions are made regarding extensions to both experiment and computation.

Author

A85-42973\*# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**BOUNDARY LAYERS ON OSCILLATING AIRFOILS**

L. W. CARR (NASA, Ames Research Center, Moffett Field, CA) and T. CEBECI (California State University, Long Beach, CA) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 6-3 to 6-10. refs

A two-point finite-difference unsteady laminar and turbulent boundary-layer computational method has been used to investigate the properties of the flow around an airfoil (NACA 0012) oscillating through angles of attack up to 18 degrees, and for reduced frequencies of 0.01 and 0.20. The unsteady potential flow was determined using the method of Geissler. The influence of transition location on stall behavior has been investigated, using both experimentally determined transition information, and transition located at the pressure peak; the results show the need for viscous-inviscid interaction in future computations of such flows.

Author

A85-42974\*# Cincinnati Univ., Ohio.

**MASSIVE SEPARATION AND DYNAMIC STALL ON A CUSPED TRAILING-EDGE AIRFOIL**

A. P. ROTHMAYER and R. T. DAVIS (Cincinnati, University, OH) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 6-11 to 6-27. refs

(Contract NGT-36-004-800; N00014-76-C-0364)

The cross-over from a predominantly attached two-dimensional flow to the bluff body form of separation is modeled via the interacting boundary layer approximation. The initial breakdown of the predominantly attached flow on a cusped trailing edge airfoil is examined using the Hilbert integral form of the unsteady interacting boundary layer equations. In addition, an interacting boundary layer technique is developed for calculating bluff body separation. This new model eliminates the severe scaling problems associated with bluff body separation through the use of a realistic inviscid eddy model, based on the infinite eddy Kirchhoff free-streamline description of separation. Brief consideration is given to the cross-over from bluff body separation to a predominantly attached flow, the extension to finite eddies and cascade flows, and the possible coupling with full, or parabolized, Navier-Stokes calculations.

Author

A85-42975\*# Cincinnati Univ., Ohio.

**ANALYSIS OF TWO-DIMENSIONAL INCOMPRESSIBLE FLOW PAST AIRFOILS USING UNSTEADY NAVIER-STOKES EQUATIONS**

K. N. GHIA, G. A. OSSWALD, and U. GHIA (Cincinnati, University, OH) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 6-29 to 6-43. refs

(Contract NAG1-465; AF-AFOSR-80-0160)

The conservative form of the unsteady Navier-Stokes equations in terms of vorticity and stream function in generalized curvilinear coordinates are used to analyze the flow structure of steady separation and unsteady flow with massive separation. The numerical method solves the discretized equations using an ADI-BGE method. The method is applied to a symmetric 12 percent thick Joukowski airfoil. A conformal clustered grid is generated; several 1-D stretching transformations are used to obtain a grid that attempts to resolve many of the multiple scales of the unsteady flow with massive separation, while maintaining the transformation metrics to be smooth and continuous in the entire flow field. Detailed numerical results are obtained for three flow configurations (1)  $Re = 1000$ ,  $\alpha = 5$  deg, (2)  $Re = 1000$ ,  $\alpha = 15$  deg, (3)  $Re = 10,000$ ,  $\alpha = 5$  deg. No artificial dissipation was added; however, lack of a fine grid in the normal direction has presently led to results which are considered qualitative, especially for case (3).

Author

A85-42977#

**FLOW OVER SURFACE-MOUNTED SEMI-BLUFF BODIES**

P. M. HANDFORD and P. BRADSHAW (Imperial College of Science and Technology, London, England) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 7-13 to 7-21. refs

To provide a test case for turbulence models in three-dimensional separated flows with simple initial conditions, measurements are in progress on half-bullet-shaped bodies mounted on a ground plane. The boundary layer that separates from the model at its base is close to 'flat plate' conditions except where it interacts with the ground plane boundary layer. Measurements in the separated flow region are made with pulsed wire anemometers.

Author

## 02 AERODYNAMICS

**A85-42978#**

### **STUDIES OF THE FLOW FIELD NEAR AN NACA 4412 AEROFOIL AT NEARLY MAXIMUM LIFT**

R. C. HASTINGS (Royal Aircraft Establishment, Aerodynamics Dept., Bedford, England) and B. R. WILLIAMS (Royal Aircraft Establishment, Aerodynamics Dept., Farnborough, England) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings . Long Beach, CA, California State University, 1985, p. 7-23 to 7-37. refs

Measurements made at a Mach number of 0.18 and a chord-based Reynolds number of  $4.2 \times 10^6$  to the 6th on a constant-chord model having an NACA 4412 airfoil section are described and compared with the results of flow field calculations. The measurements include static pressure distributions on the wing surface and on the wind tunnel walls above and below the mid-span section of the wing. The main emphasis in the experiment was, however, on defining the development of the upper surface boundary layer through separation (at about 20 percent chord ahead of the trailing-edge) and on into the wake, making extensive use of laser anemometry. The flow field calculations are of the semi-inverse kind in which an inverse momentum-integral treatment of the shear flow, used to avoid difficulties at separation, is coupled to a direct solution of the inviscid flow problem. Author

**A85-42979#**

### **AEROFOILS AT LOW REYNOLDS NUMBERS - PREDICTION AND EXPERIMENT**

P. M. RENDER (Aircraft Research Association, Bedford, England), J. L. STOLLERY (Cranfield Institute of Technology, Cranfield, England), and B. R. WILLIAMS (Royal Aircraft Establishment, Farnborough, England) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings . Long Beach, CA, California State University, 1985, p. 7-39 to 7-46. Research supported by the Ministry of Defence. refs

Experimental data for three widely different airfoils have been obtained, taking into account the Goettingen 797, NACA 64(3)-418, and Wortmann FX63-137. Tests regarding four modified versions of the Wortmann section were conducted. In these tests the undercamber was progressively removed. The Reynolds numbers involved were in the range from 300,000 to 1,000,000. It is pointed out that of the airfoils tested the Wortmann section had the best lift. A new wing for an existing full-scale RPV research model was, therefore, built, and the complete vehicle was tested in a 24 ft wind tunnel. Attention is given to details concerning the wind tunnel tests, the experimental results, the computational program, and comparisons between theory and experiment. G.R.

**A85-42980\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### **COMPUTATION OF THREE-DIMENSIONAL SHOCK-WAVE/TURBULENCE BOUNDARY-LAYER INTERACTION FLOWS**

C. C. HORSTMAN, M. I. KUSSOY, and W. K. LOCKMAN (NASA, Ames Research Center, Moffett Field, CA) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings . Long Beach, CA, California State University, 1985, p. 8-13 to 8-23. refs

Solutions of the Reynolds-averaged Navier-Stokes equations, employing a two-equation turbulence model, are presented and compared with measurements from a series of supersonic shock-wave/boundary-layer interaction experiments. The test flows include swept-compression corners and axisymmetric bodies with either skewed or segmented conical flares. The solutions correctly predict all major qualitative features of the flow field. However, for flow fields with large separated zones, significant quantitative differences are observed between the computed and experimental results. Possible reasons for these differences are discussed. Author

**A85-42982#**

### **NUMERICAL SIMULATION OF SHOCK/BOUNDARY-LAYER INTERACTION USING A FINITE-VOLUME RUNGE-KUTTA TIME-STEPPING SCHEME**

R. K. AGARWAL and J. E. DEESE (McDonnell Douglas Research Laboratories, St. Louis, MO) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings . Long Beach, CA, California State University, 1985, p. 8-33 to 8-43. Research supported by the McDonnell Douglas Independent Research and Development Program. refs

An efficient numerical algorithm is presented for solving the unsteady compressible Navier-Stokes equations. The solution procedure is based on a finite-volume Runge-Kutta time-stepping scheme developed by Jameson, Schmidt, and Turkel. The algorithm is used to calculate the flow-fields due to shock/boundary layer interaction on a flat plate and an airfoil. Numerical results are compared with the calculations of other investigators, asymptotic theory, and experimental data. Author

**A85-42983#**

### **THE EFFECT OF BOATTAILING OF A PROJECTILE IN TRANSONIC FLOW**

W. L. CHOW (Illinois, University, Urbana) IN: Symposium on Numerical and Physical Aspects of Aerodynamic flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings . Long Beach, CA, California State University, 1985, p. 9-15 to 9-22. refs (Contract DAAG29-83-K-0043)

The base pressure problem for a transonic flow past a blunt trailing edged projectile was continued on the basis of an equivalent body approach. Specifically, the effect of boattailing on the forebody pressure distribution and the base pressure was examined. Within the limited range of small boattail angles, it was observed that the reduction of the base drag outweighed the additional drag incurred on the boattail indicating its favorable interference. It was recognized that more precise simulation of turbulence was needed before more accurate evaluation on the optimum boattail configuration could be carried out. Computations for two freestream Mach numbers ( $M = 0.9$  and  $1.2$ ) were performed for different boattail angles. Comparison with the experimental data is presented whenever available. Reasonably good agreement in the pressure distribution on the forebody was observed. Author

**A85-42985#**

### **COMPUTATION OF VELOCITY AND PRESSURE VARIATION ACROSS THICK TURBULENCE STERN FLOWS**

T. T. HUANG and M.-S. CHANG (David W. Taylor Naval Ship Research and Development Center, Bethesda, MD) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings . Long Beach, CA, California State University, 1985, p. 10-1 to 10-20. refs

(Contract NAVY TASK ZR0230101; NAVY TASK SR0230101)

Of the two viscous-inviscid interaction computation procedures presented, one solves the parabolized, Reynolds-averaged Navier-Stokes equations by means of streamline coordinates and the k-epsilon turbulence model, while the other solves the simpler, thin boundary layer equations by means of the Lighthill (1958) displacement body concept and the revised mixing length for a thick boundary layer. The prediction of surface pressure coefficients and frictional velocities, and normalized axial and radial velocities, by means of freestream and cross-stream pressure coefficients are in close agreement with measured data for four models having attached flow. These procedures can be used as a design tool for the computation of the cross-stream velocity and pressure variation across the thick stern boundary layer of many naval applications. O.C.

A85-42986#

**FLOW CHARACTERISTICS OF A BODY OF REVOLUTION AT INCIDENCE**

H. U. MEIER (DFVLR, Institut fuer experimentelle Stromungsmechanik, Goettingen, West Germany) and T. CEBECI (California State University, Long Beach) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 10-21 to 10-33. refs (Contract NSF MEA-80-18565)

Experimental boundary layer data obtained on and around a prolate spheroid with imposed transition in subsonic flow at an angle of attack of 10 degrees are reported. A representative sample of measured results for natural transition is also presented in order to demonstrate the effect of imposed transition. A calculation method of Cebeci, Khattab and Stewartson is described and results are presented for different transition patterns and are examined in relation to the experimental results. Requirements for the further development of predicting transition in three-dimensional flows and interactive calculation procedures as well as suggestions for additional experiments are given. Author

A85-42987#

**3-D SEPARATION ON BODIES WITH ELLIPTIC CROSS-SECTION AND NEAR ROOT-SECTION OF WING-BODY COMBINATION**

N. NISHIKAWA (Chiba University, Japan) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 10-35 to 10-43. refs

Three-dimensional boundary layer equations are solved for some simple bodies of elliptic cross section or wing-body combinations. Nose coordinates originally devised for a body of revolution are applied on the symmetry line of a body with elliptic cross section, and an interesting dependence of the location of separation point on slenderness of the cross section is predicted. For elliptic paraboloids the nose separation is investigated and results show that as the transverse cross section is elongated the separation occurs earlier. For ellipsoids the separation near the aft end of the body is explored and the delay of separation is observed on the windward side symmetry line, and vice versa on the leeside symmetry line. The finite difference solutions are also obtained for the general flowfield including separation line near the root section of the wing for two types of wing-ellipsoid combinations. Author

A85-42988\*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**A THREE-DIMENSIONAL BOUNDARY-LAYER ANALYSIS INCLUDING HEAT-TRANSFER AND BLADE-ROTATION EFFECTS**

V. N. VATSA (NASA, Langley Research Center, Hampton, VA) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 10-45 to 10-59. refs (Contract NAS3-23716)

An analysis has been developed for calculating three-dimensional viscous flows over arbitrary bodies through the solution of complete three-dimensional boundary-layer equations. The governing equations include the effect of blade rotation and are written in nonorthogonal surface-fitted coordinates to allow maximum flexibility. A coupled finite-difference numerical scheme is used for solving the governing equations. The accuracy of this scheme has been assessed through comparisons with known analytical/experimental results for several test cases. The present analysis has then been applied to compute viscous flows over a turbine endwall and airfoil suction surface, and fairly good correlation has been obtained with available experimental data for surface heat transfer and viscous streamline skewing. Author

A85-42990#

**PREDICTION OF DYNAMIC SEPARATION CHARACTERISTICS USING A TIME-STEPPING VISCID/INVISCID APPROACH**

B. MASKEW and F. A. DVORAK (Analytical Methods, Inc., Redmond, WA) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 11-13 to 11-25. refs

It is pointed out that flow separation on the lifting surfaces of a vehicle at high angle of attack is always complicated by a certain degree of unsteadiness. The complexity of the separated flow is even greater in cases in which the vehicle itself is undergoing unsteady motion or deformation, or in which the vehicle enters a different flow field rapidly. In such cases the phenomenon of dynamic stall can be observed. No completely satisfactory theoretical method exists currently for predicting the dynamic stall characteristics for new untested shapes, not even for the two-dimensional case. The present investigation is concerned with a possible theoretical approach for predicting dynamic separation characteristics. The considered approach permits, in principle, the inclusion of both trailing-edge and leading-edge stall with vortex passage. The method, developed for the three-dimensional case, is applicable to arbitrary configurations and to general motions. G.R.

A85-42991#

**COMPUTATION OF TURBULENT SEPARATED FLOWS OVER WINGS**

J. C. WAI, J. C. BAILLIE, and H. YOSHIHARA (Boeing Military Airplane Co., Seattle, WA) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 11-27 to 11-38.

Two separated cases are calculated. The first is for a swept wing at transonic speeds where the exact potential-code (FL028) is coupled to the direct mode three-dimensional integral boundary layer/wake code. The second is the case of the secondary separation over a sharp-nosed, highly swept delta wing at low speeds where the same boundary layer code is coupled to the inviscid Leading Edge Vortex panel code. Test/theory comparisons are given in both cases. Author

A85-42992#

**AN INTERACTIVE SCHEME FOR THREE-DIMENSIONAL TRANSONIC FLOWS**

T. CEBECI, L. T. CHEN, K. C. CHANG, and C. C. PEAVEY (Douglas Aircraft Co., Long Beach, CA) IN: Symposium on Numerical and Physical Aspects of Aerodynamic Flows, 3rd, Long Beach, CA, January 21-24, 1985, Proceedings. Long Beach, CA, California State University, 1985, p. 11-39 to 11-49. refs

An interactive boundary-layer method is described for compressible flows with and without flow separation and comparisons are made between this method and those due to LeBalleur and Carter. Results are presented for two- and three-dimensional transonic flows to further explore the features of the method. Author

A85-43050#

**ON THE WAKE OF A PITCHING AIRFOIL**

D. P. TELIONIS, D. T. MOOK (Virginia Polytechnic Institute and State University, Blacksburg), D. S. MATHIOULAKIS, and M. J. KIM American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985, 9 p. refs (Contract AF-AFOSR-82-0228) (AIAA PAPER 85-1621)

This is an experimental and numerical study of the stretching and rolling of a free-shear layer released at the trailing edge of a pitching airfoil. Experimental data were obtained in a water tunnel by Laser-Doppler Velocimetry in the wake of a pitching NACA 0012. The numerical calculations are based on a panel method coupled with discrete vortex dynamics. Both experiment and theory indicate that the layer quickly rolls up into concentrating



resembles the organization of the wake of a bluff body. It is demonstrated that the flowfield is controlled entirely by the inviscid self-interaction of vorticity. Author

**A85-43053#**

**APPLICATION OF THE METHOD OF QUASI-CONTINUOUS VORTICITY DISTRIBUTION OVER THE SKELETON SURFACE FOR AEROPLANE WING DESIGN**

K. KUBRYNSKI Instytut Lotnictwa, Prace (ISSN 0509-6669), no. 99, 1984, p. 41-58. In Polish. refs

The subject matter of the present paper are the principles of the QVLM method based on the classical theory of a lifting surface and the linearized theory of subsonic compressible flow. Some of the advantages of that method over the popular method of vortex network (VLM) are presented. On the basis of the analysis made a program is established for computing the aerodynamic characteristics and the load distribution over a wing of any form and the geometry of the skeleton surface of a wing with prescribed load distribution. Computation has been performed for a number of wings. The characteristics and the skeleton surfaces obtained are confronted with the literature data available (theoretical and experimental), the agreement being found to be satisfactory. Author

**A85-43226#**

**WIND-TUNNEL EXPERIMENTAL INVESTIGATION ON FLAP SPANWISE BLOWING**

X. TIAN, X. LI, and J. ZHAO (Harbin Aerodynamics Research Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 5, Dec. 1984, p. 357-365. In Chinese, with abstract in English.

Force measurements of an aircraft model in a delta wing configuration were obtained using spanwise blowing and flow visualization. The measurements were carried out in the FL-8 and FL-5 wind tunnels of the Harbin Aerodynamics Research Institute in Harbin, People's Republic of China. Comparative tests of two new blowing techniques, flap spanwise blowing and a blown flap method were also performed. It is found that the flap shoulder vortex was generated over the flap instead of the jet vortex when flap blowing was applied at a high deflection angle. The velocity of the flap shoulder vortex was related to the entrainment effect of the jet. Lift augmentation observed during flap spanwise blowing could not be attributed to boundary layer control, but was mainly due to vortex control. Lift increments due to flap spanwise blowing consist of flap and a wing component, respectively. It is shown that life increments approaching those of the blown flap may be possible using conventional jet engines with optimized nozzle parameters. I.H.

**A85-43227#**

**EXPERIMENTAL STUDY ON THE BEHAVIOR OF THREE-DIMENSIONAL TURBULENT BOUNDARY LAYER INDUCED BY A STRAIGHT WING ERECTED ON A FLAT PLATE**

D. XIN, X. DENG, Y. CHEN, and C. WANG (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 5, Dec. 1984, p. 366-377. In Chinese, with abstract in English. refs

The dynamic behavior of a three-dimensional boundary layer was investigated in the flow region of a straight wing attached to a flat plate, at low and subsonic speeds. The effects of pressure gradients and streamline curvature on the distribution of mean velocity and turbulence are discussed. On the basis of the experimental results, it is concluded that: (1) the application of the wall and wake law of a two-dimensional turbulent boundary layer to the three-dimensional case is reasonable as long as the pressure gradients and streamline curvature are not too severe; and (2) peaks in the distribution of turbulent stresses appear to move away from the wall as the adverse pressure gradient increases, and to flatten as streamline curvature increases. The behavior of the three-dimensional boundary layer at subsonic speeds was qualitatively similar to that in the low speed case. I.H.

**A85-43231#**

**AN EXPERIMENTAL INVESTIGATION ON LOCATION OF BOUNDARY LAYER TRANSITION ON THE NACA 0012 USING SURFACE HOT FILM GAGES**

T. WANG (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 5, Dec. 1984, p. 401-405. In Chinese, with abstract in English.

Hot film gages were attached flush to the upper surface of a NACA-type 0012 airfoil in order to locate the boundary layer transitions corresponding to a range of distances from the leading edge. The measurements were carried out in a low-speed wind tunnel at Nanjing Aeronautical Institute. During the wind-tunnel tests, Reynolds numbers were kept constant at 200,000 Re(b), while the angle of attack of the airfoil was varied continuously. The locations on the airfoil of boundary layer separation and turbulent boundary layer attachment are shown in a diagram. It is found that the location of boundary layer transitions using hot film gages is a feasible and practical technique. I.H.

**A85-43234#**

**EXPERIMENTAL STUDY ON AIR JET VORTEX GENERATOR**

S. ZHANG and F. LI (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 5, Dec. 1984, p. 425-435. In Chinese, with abstract in English.

It is shown on the basis of a series of experimental results that the characteristics of separated and unseparated boundary layers can be optimized using an air jet vortex generator. The traces and strength behind the jet were found using the fluorescent thread method. Flow was directed at the jet at different velocities and lateral injection angles less than 90 degrees. It is found that the vortex strength reached a maximum when the lateral injection angle was about 30 degrees. A model of the mechanisms of vortex formation in air vortex generator is proposed based on the results of dye visualizations in wind tunnel tests. I.H.

**A85-43239#**

**SOME DEVELOPMENTS IN VORTEX MOTION RESEARCH**

M. LIU and W. SU (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Feb. 1985, p. 1-12. In Chinese, with abstract in English. refs

Recent research results on the flow patterns around delta wings and their boundaries, the topological analysis of separated flows and vortex flows, vortex breakdown, and controlled separation and vortex interaction are reported. Flow patterns about upper and lower surfaces of a series of delta plate wings with sharpened leading-edge sweepback of 15 to 85 deg, at angles of attack up to 90 deg, and at low speeds are given. The application of qualitative theory of differential equations and topology to analyze the concentrated vortex of a slender wing and the spiral flow about a moderate sweepback cropped delta wing is considered. The controlled separation of three-dimensional flows in air vehicle configuration design is addressed. C.D.

**N85-29917\*#** Rockwell International Corp., Los Angeles, Calif. **NONLINEAR POTENTIAL ANALYSIS TECHNIQUES FOR SUPERSONIC-HYPERSONIC CONFIGURATION DESIGN Final Report**

W. C. CLEVER and V. SHANKAR 28 Mar. 1983 88 p refs (Contract NAS1-15820)

(NASA-CR-166078; NAS 1.26:166078; NA-82-1170) Avail: NTIS HC A05/MF A01 CSCL 01A

Approximate nonlinear inviscid theoretical techniques for predicting aerodynamic characteristics and surface pressures for relatively slender vehicles at moderate hypersonic speeds were developed. Emphasis was placed on approaches that would be responsive to preliminary configuration design level of effort. Second order small disturbance and full potential theory was utilized to meet this objective. Numerical pilot codes were developed for relatively general three dimensional geometries to evaluate the capability of the approximate equations of motion considered. Results from the computations indicate good agreement with higher order solutions and experimental results for a variety of wing,

body and wing-body shapes for values of the hypersonic similarity parameter  $M$  delta approaching one. Case computational times of a minute were achieved for practical aircraft arrangements.

Author

**N85-29918\*#** Kentron International, Inc., Hampton, Va.  
**APPLICATION OF AN AERODYNAMIC ANALYSIS METHOD INCLUDING ATTAINABLE THRUST ESTIMATES TO LOW SPEED LEADING-EDGE FLAP DESIGN FOR SUPERSONIC CRUISE VEHICLES**

H. W. CARLSON Mar. 1982 28 p refs

(Contract NAS1-16000)

(NASA-CR-165843; NAS 1.26:165843) Avail: NTIS HC A03/MF A01 CSCL 01A

A study of low speed leading-edge flap design for supersonic cruise vehicle was conducted. Wings with flaps were analyzed with the aid of a newly developed subsonic wing program which provides estimates of attainable leading-edge thrust. Results indicate that the thrust actually attainable can have a significant influence on the design and that the resultant flaps can be smaller and simpler than those resulting from more conventional approaches.

R.J.F.

**N85-29919\*#** Wichita State Univ., Kans.  
**ADDITIONAL FLOW FIELD STUDIES OF THE GA(W)-1 AIRFOIL WITH 30-PERCENT CHORD FOWLER FLAP INCLUDING SLOT-GAP VARIATIONS AND COVE SHAPE MODIFICATIONS Final Report**

W. H. WENTZ, JR. and C. OSTOWARI Washington NASA May 1983 168 p refs

(Contract NGR-17-003-021)

(NASA-CR-3687; NAS 1.26:3687; AR-79-3) Avail: NTIS HC A08/MF A01 CSCL 01A

Experimental measurements were made to determine the effects of slot gap opening and flap cove shape on flap and airfoil flow fields. Test model was the GA(W)-1 airfoil with 0.30c Fowler flap deflected 35 degrees. Tests were conducted with optimum, wide and narrow gaps, and with three cove shapes. Three test angles were selected, corresponding to pre-stall and post-stall conditions. Reynolds number was 2,200,000 and Mach number was 0.13. Force, surface pressure, total pressure, and split-film turbulence measurements were made. Results were compared with theory for those parameters for which theoretical values were available.

Author

**N85-29920\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.  
**INVISCID ANALYSIS OF TWO SUPERCRITICAL LAMINAR-FLOW-CONTROL AIRFOILS AT DESIGN AND OFF-DESIGN CONDITIONS**

D. O. ALLISON Jun. 1983 22 p refs

(NASA-TM-84657; L-15571; NAS 1.15:84657) Avail: NTIS HC A02/MF A01 CSCL 01A

Inviscid transonic flow results are provided at design and off design conditions for two supercritical laminar flow control airfoils. The newer airfoil, with its lower suction requirements for full chord laminar flow, has a higher design Mach number, steeper pressure gradients, a more positive pressure level in the forward region of the lower surface, and a recovery to a less positive pressure at the trailing edge. The two dimensional design Mach numbers for the two airfoils are 0.755 and 0.730 at a common design lift coefficient of 0.60, and their thickness to chord ratios are 0.131 and 0.135, respectively. Off design shock formation characteristics are similar for the two airfoils over a range of Mach numbers between 0.6 and 0.8 and lift coefficients from 0.4 to 0.7. The newer airfoil is similar to the one used in a large chord swept model experiment designed for the Langley 8 Foot Transonic Pressure Tunnel.

Author

**N85-29921\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**LEE-SIDE FLOW OVER DELTA WINGS AT SUPERSONIC SPEEDS**

D. S. MILLER and R. M. WOOD Jun. 1985 154 p refs  
 (NASA-TP-2430; L-15888; NAS 1.60:2430) Avail: NTIS HC A08/MF A01 CSCL 01A

An experimental investigation of the lee-side flow on sharp leading-edge delta wings at supersonic speeds has been conducted. Pressure data were obtained at Mach numbers from 1.5 to 2.8, and three types of flow-visualization data (oil-flow, tuft, and vapor-screen) were obtained at Mach numbers from 1.7 to 2.8 for wing leading-edge sweep angles from 52.5 deg to 75 deg. From the flow-visualization data, the lee-side flows were classified into seven distinct types and a chart was developed that defines the flow mechanism as a function of the conditions normal to the wing leading edge, specifically, angle of attack and Mach number. Pressure data obtained experimentally and by a semiempirical prediction method were employed to investigate the effects of angle of attack, leading-edge sweep, and Mach number on vortex strength and vortex position. In general, the predicted and measured values of vortex-induced normal force and vortex position obtained from experimental data have the same trends with angle of attack, Mach number, and leading-edge sweep; however, the vortex-induced normal force is underpredicted by 15 to 30 percent, and the vortex spanwise location is overpredicted by approximately 15 percent.

Author

**N85-29922\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**EXPERIMENTAL AND THEORETICAL STUDY OF THE LONGITUDINAL AERODYNAMIC CHARACTERISTICS OF DELTA AND DOUBLE-DELTA WINGS AT MACH NUMBERS OF 1.60, 1.90, AND 2.16**

R. M. WOOD and P. F. COVELL Jul. 1985 122 p refs  
 (NASA-TP-2433; L-15899; NAS 1.60:2433) Avail: NTIS HC A06/MF A01 CSCL 01A

An experimental and theoretical study was conducted to investigate the supersonic aerodynamic characteristics of delta and double-delta wings. Testing was conducted in the Langley Unitary Plan Wind Tunnel at Mach numbers of 1.60, 1.90, and 2.16. The double-delta wings exhibited lower zero-lift drag values than the delta wings having the same aspect ratio, whereas delta wings provided the lower drag due to lift. Deflections of the trailing-edge flaps for pitch control revealed that the induced aerodynamic forces were only a function of the flap planform and were independent of wing planform. The supporting theoretical analysis showed that the supersonic design and analysis system (SDAS) did not consistently predict all the longitudinal aerodynamic characteristics of the low-sweep, low-fineness-ratio wing-body configurations under investigation.

Author

**N85-29923\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**EFFECT OF LEADING-EDGE LOAD CONSTRAINTS ON THE DESIGN AND PERFORMANCE OF SUPERSONIC WINGS**

C. M. DARDEN Jul. 1985 78 p refs  
 (NASA-TP-2446; L-15841; NAS 1.60:2446) Avail: NTIS HC A05/MF A01 CSCL 01A

A theoretical and experimental investigation was conducted to assess the effect of leading-edge load constraints on supersonic wing design and performance. In the effort to delay flow separation and the formation of leading-edge vortices, two constrained, linear-theory optimization approaches were used to limit the loadings on the leading edge of a variable-sweep planform design. Experimental force and moment tests were made on two constrained camber wings, a flat uncambered wing, and an optimum design with no constraints. Results indicate that vortex strength and separation regions were mildest on the severely and moderately constrained wings.

Author

**N85-29924\*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.  
**NACELLE/PYLON/WING INTEGRATION ON A TRANSPORT MODEL WITH A NATURAL LAMINAR FLOW NACELLE**  
 M. LAMB, W. K. AABEYOUNIS, and J. C. PATTERSON, JR. Jul. 1985 61 p refs  
 (NASA-TP-2439; L-15907; NAS 1.60:2439) Avail: NTIS HC A04/MF A01 CSCL 01A

Tests were conducted in the Langley 16-Foot Transonic Tunnel at free-stream Mach numbers from 0.70 to 0.82 and angles of attack from -2.5 deg to 4.0 deg to determine if nacelle/pylon/wing integration affects the achievement of natural laminar flow on a long-duct flow-through nacelle for a high-wing transonic transport configuration. In order to fully assess the integration effect on a nacelle designed to achieve laminar flow, the effects of fixed and free nacelle transitions as well as nacelle longitudinal position and pylon contouring were obtained. The results indicate that the ability to achieve laminar flow on the nacelle is not significantly altered by nacelle/pylon/wing integration. The increment in installed drag between free and fixed transition for the nacelles on symmetrical pylons is essentially the calculated differences between turbulent and laminar flow on the nacelles. The installed drag of the contoured pylon is less than that of the symmetrical pylon. The installed drag for the nacelles in a rearward position is greater than that for the nacelles in a forward position. Author

**N85-29925\*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.  
**WIND TUNNEL RESULTS OF ADVANCED HIGH SPEED PROPELLERS IN THE TAKEOFF, CLIMB AND LANDING OPERATING REGIMES**  
 G. L. STEFKO and R. J. JERACKI 1985 23 p refs Prepared for the 21st Joint Propulsion Conf., Monterey, Calif., 8-10 Jul. 1985; sponsored in part by AIAA, SAE, ASME and ASCE  
 (NASA-TM-87054; E-2621; NAS 1.15:87054; AIAA-85-1259) Avail: NTIS HC A02/MF A01 CSCL 01A

Low speed wind tunnel performance tests of two advanced propellers were completed. The 62.2 cm diameter adjustable pitch models were tested at Mach numbers typical of takeoff, initial climbout, and landing speeds in the 10 by 10 ft Supersonic Wind Tunnel. Both models had eight blades and a cruise design point operating condition of 0.80 Mach number, 10,668 km S.A. altitude, 243.8 m/s tip speed and a high power loading of 301 kW sq m. No adverse or unusual low speed operating conditions were found during the test with either the straight blade SR-2 or the 45 deg swept SR-3 propellers. The 45 deg swept propeller efficiency exceeded the straight blade efficiency by 4 to 5%. Typical net efficiencies of the straight and 45 deg swept propeller at a Mach 0.20 takeoff condition were 50.2 and 54.9% respectively. At a Mach 0.34 climb condition, the efficiencies were 53.7 and 59.1%. Reverse thrust data indicates that these propellers are capable of producing more reverse thrust at Mach 0.20 than a high bypass turbofan engine at Mach 0.20. E.A.K.

**N85-29926\*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.  
**HIGH REYNOLDS NUMBER TESTS OF A NASA SC(3)-0712(B) AIRFOIL IN THE LANGLEY 0.3-METER TRANSONIC CRYOGENIC TUNNEL**  
 W. G. JOHNSON, JR., A. S. HILL, and O. EICHMANN Jun. 1985 168 p refs  
 (NASA-TM-86371; L-15909; NAS 1.15:86371) Avail: NTIS HC A08/MF A01 CSCL 01A

A wind tunnel investigation of a NASA 12-percent-thick, advanced-technology supercritical airfoil was conducted in the Langley 0.3-Meter Transonic Cryogenic Tunnel (TCT). This investigation represents another in the series of NASA/U.S. industry two-dimensional airfoil studies to be completed in the Advanced Technology Airfoil Tests program. Test temperature was varied from 220 K to 96 K at pressures ranging from 1.2 to 4.3 atm. Mach number was varied from 0.60 to 0.80. These variables provided a Reynolds number range from 4,400,000 to 40,000,000 based on a 15.24-cm (6.0-in.) airfoil chord. This investigation was

designed to test a NASA advanced-technology airfoil from low to flight-equivalent Reynolds numbers, provide experience in cryogenic wind tunnel model design and testing techniques, and demonstrate the suitability of the 0.3-m TCT as an airfoil test facility. The aerodynamic results are presented as integrated force and moment coefficients and pressure distributions. Data are included which demonstrate the effects of fixed transition, Mach number, and Reynolds number on the aerodynamic characteristics. Also included are remarks on the model design, the model structural integrity, and the overall test experience. R.J.F.

**N85-29927\*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.  
**PRESSURE DISTRIBUTION FROM HIGH REYNOLDS NUMBER TESTS OF A NASA SC(3)-0712(B) AIRFOIL IN THE LANGLEY 0.3-METER TRANSONIC CRYOGENIC TUNNEL**  
 W. G. JOHNSON, JR., A. S. HILL, and O. EICHMANN Jul. 1985 410 p refs  
 (NASA-TM-86370; L-15908; NAS 1.15:86370) Avail: NTIS HC A18/MF A01 CSCL 01A

A wind tunnel investigation of a NASA 12-percent-thick, advanced-technology supercritical airfoil was conducted in the Langley 0.3-Meter Transonic Cryogenic Tunnel (TCT). This investigation represents another in the series of NASA/U.S. industry two-dimensional airfoil studies to be completed in the Advanced Technology Airfoil Tests program. Test temperature was varied from 220 K to 96 K at pressures ranging from 1.2 to 4.3 atm. Mach number was varied from 0.50 to 0.80. This investigation was designed to: (1) test a NASA advanced-technology airfoil from low to flight equivalent Reynolds numbers, (2) provide experience in cryogenic wind-tunnel model design and testing techniques, and (3) demonstrate the suitability of the 0.3-m TCT as an airfoil test facility. All the test objectives were met. The pressure data are presented without analysis in tabulated format and as plots of pressure coefficient versus position on the airfoil. This report was prepared for use in conjunction with the aerodynamic coefficient data published in NASA-TM-86371. Data are included which demonstrate the effects of fixed transition. Also included are remarks on the model design and fabrication. B.W.

**N85-29928\*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.  
**LOW-SPEED WIND-TUNNEL TESTS OF AN ADVANCED EIGHT-BLADED PROPELLER**  
 P. L. COE, JR., G. L. GENTRY, JR., and D. M. DUNHAM Jul. 1985 48 p refs  
 (NASA-TM-86364; L-15898; NAS 1.15:86364) Avail: NTIS HC A03/MF A01 CSCL 01A

As part of a research program on advanced turboprop aircraft aerodynamics, a low-speed wind-tunnel investigation was conducted to document the basic performance and force and moment characteristics of an advanced eight-bladed propeller. The results show that in addition to the normal force and pitching moment produced by the propeller/nacelle combination at angle of attack, a significant side force and yawing moment are also produced. Furthermore, it is shown that for test conditions wherein compressibility effects can be ignored, accurate simulation of propeller performance and flow fields can be achieved by matching the nondimensional power loading of the model propeller to that of the full-scale propeller. Author

**N85-29929\*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.  
**VAPOR-SCREEN TECHNIQUE FOR FLOW VISUALIZATION IN THE LANGLEY UNITARY PLAN WIND TUNNEL**  
 O. A. MORRIS, W. A. CORLETT, D. L. WASSUM, and C. D. BABB Washington Jul. 1985 41 p refs  
 (NASA-TM-86384; L-15902; NAS 1.15:86384) Avail: NTIS HC A03/MF A01 CSCL 01A

The vapor-screen technique for flow visualization, as developed for the Langley Unitary Plan Wind Tunnel, is described with evaluations of light sources and photographic equipment. Test parameters including dew point, pressure, and temperature were

varied to determine optimum conditions for obtaining high-quality vapor-screen photographs. The investigation was conducted in the supersonic speed range for Mach numbers from 1.47 to 4.63 at model angles of attack up to 35 deg. Vapor-screen photographs illustrating various flow patterns are presented for several missile and aircraft configurations. Examples of vapor-screen results that have contributed to the understanding of complex flow fields and provided a basis for the development of theoretical codes are presented with reference to other research. Author

**N85-29930\*#** Boston Univ., Mass. Dept. of Mathematics.  
**A FIRST-ORDER TIME-DOMAIN GREEN'S FUNCTION APPROACH TO SUPERSONIC UNSTEADY FLOW** Final Report  
 M. I. FREEDMAN and K. TSENG Apr. 1985 39 p refs  
 (Contract NAG1-276)  
 (NASA-CR-172208; NAS 1.26:172208) Avail: NTIS HC A03/MF A01 CSCL 01A

A time-domain Green's Function Method for unsteady supersonic potential flow around complex aircraft configurations is presented. The focus is on the supersonic range wherein the linear potential flow assumption is valid. The Green's function method is employed in order to convert the potential-flow differential equation into an integral one. This integral equation is then discretized, in space through standard finite-element technique, and in time through finite-difference, to yield a linear algebraic system of equations relating the unknown potential to its prescribed co-normalwash (boundary condition) on the surface of the aircraft. The arbitrary complex aircraft configuration is discretized into hyperboloidal (twisted quadrilateral) panels. The potential and co-normalwash are assumed to vary linearly within each panel. Consistent with the spatial linear (first-order) finite-element approximations, the potential and co-normalwash are assumed to vary linearly in time. The long range goal of our research is to develop a comprehensive theory for unsteady supersonic potential aerodynamics which is capable of yielding accurate results even in the low supersonic (i.e., high transonic) range. R.J.F.

**N85-29931\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.  
**UNSTEADY TRANSONIC FLOW CALCULATIONS FOR INTERFERING LIFTING SURFACE CONFIGURATIONS**  
 J. T. BATINA May 1985 13 p refs Presented at the 18th AIAA Fluid Dyn., Plasma Dyn. and Lasers Conf., Cincinnati, 16-18 Jul. 1985  
 (NASA-TM-86432; NAS 1.15:86432; AIAA-PAPER-85-1711)  
 Avail: NTIS HC A02/MF A01 CSCL 01A

Unsteady transonic flow calculations are presented for aerodynamically interfering lifting surface configurations. Calculations are performed by extending the XTRAN3S (Version 1.5) unsteady transonic small-disturbance code to allow the treatment of an additional lifting surface. The research was conducted as a first-step toward developing the capability to treat a complete flight vehicle. Grid generation procedures for swept tapered interfering lifting surface applications of XTRAN3S are described. Transonic calculations are presented for wing-tail and canard-wing configurations for several values of mean angle of attack. The effects of aerodynamic interference on transonic steady pressure distributions and steady and oscillatory spanwise lift distributions are demonstrated. Results due to wing, tail, or canard pitching motions are presented and discussed in detail. Author

**N85-29932\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.  
**A METHOD FOR COMPUTING THE CORE FLOW IN THREE-DIMENSIONAL LEADING-EDGE VORTICES** Ph.D. Thesis  
 - North Carolina State Univ.  
 J. M. LUCKRING 1985 202 p refs  
 (NASA-TM-87489; NAS 1.15:87489) Avail: NTIS HC A10/MF A01 CSCL 01A

A theory is presented for calculating the flow in the core of a separation-induced leading-edge vortex. The method is based on matching inner and outer representations of the vortex. The inner model of the vortex is based on the quasicylindrical Navier-Stokes

equations; the flow is assumed to be steady, axially symmetric, and incompressible and in addition, gradients in the radial direction are assumed to be much larger than gradients in the axial direction. The outer model is based on the three-dimensional free-vortex-sheet theory, a higher-order panel method which solves the Prandtl-Glauert equation including nonlinear boundary conditions pertinent to the concentrated vorticity representation of the leading edge vortex. The resultant flow is evaluated a posteriori for evidence of incipient vortex breakdown and the critical helix angle concept, in conjunction with an adverse longitudinal pressure gradient, is found to correlate well with the occurrence of vortex breakdown at the trailing edge of delta, arrow, and diamond wings. B.W.

**N85-29933\*#** Kansas Univ. Center for Research, Inc., Lawrence.  
**APPLICATION OF TWO-DIMENSIONAL UNSTEADY AERODYNAMIC TO A FREE-TIP ROTOR RESPONSE ANALYSIS**  
 L. YATES (Russmark, Inc., Cupertino, Calif.) and H. KUMAGAI May 1985 67 p refs  
 (Contract NCC2-175)  
 (NASA-CR-177348; NAS 1.26:177348; KU-FRL-568-2) Avail: NTIS HC A04/MF A01 CSCL 01A

The free-tip rotor utilizes a rotor blade tip which is structurally decoupled from the blade inboard section. The tip is free to pitch about its own pitch axis to respond to the local flow angularity changes. The tip also experiences the heaving motion due to the flapping of the rotor blade. For an airfoil in any pitching and heaving motion which can be expanded into a Fourier series, the lift and moment calculated by Theodoren's theory is simply the linear combination of the lift and moment calculated for each harmonic. These lift and moment are then used to determine the response of the free-tip rotor. A parametric study is performed to determine the effect of mechanical damping, mechanical spring, sweep, friction, and a constant control moment on the free-tip rotor response characteristics and the resulting azimuthal lift distributions. The results showed that the free-tip has the capability to suppress the oscillatory lift distribution around the azimuth and to eliminate a significant negative life peak on the advancing tip. This result agrees with the result of the previous analysis based on the steady aerodynamics. Author

**N85-29934\*#** Boeing Military Airplane Development, Wichita, Kans.  
**B-52B/DTV (DROP TEST VEHICLE) FLIGHT TEST RESULTS: DROP TEST MISSIONS**  
 L. J. DOTY 14 May 1985 18 p refs  
 (Contract NAS8-35016)  
 (NASA-CR-171530; NAS 1.26:171530; D500-10855-1) Avail: NTIS HC A02/MF A01 CSCL 01A

The NASA test airplane, B-52B-008, was a carrier for drop tests of the shuttle booster recovery parachute system. The purpose of the test support by Boeing was to monitor the vertical loads on the pylon hooks. The hooks hold the Drop Test Vehicle to the B-52 pylon during drop test missions. The loads were monitored to assure the successful completion of the flight and the safety of the crew. Author

**N85-29935#** Calspan Field Services, Inc., Arnold AFS, Tenn.  
**TWO APPROACHES FOR THE PREDICTION OF PLUME-INDUCED SEPARATION** Final Report, Oct. 1982 - Jan. 1984  
 J. H. FOX AEDC Apr. 1985 57 p  
 (AD-A154098; AEDC-TR-84-18) Avail: NTIS HC A04/MF A01 CSCL 12A

A comparison with available measured data of the numerically predicted location of plume-induced separation on the afterbody of a bluff-base missile configuration at supersonic speed is discussed. A modified version of the implicit, three-dimensional Pulliam-Steger thin-layer Navier-Stokes code was used. The principal modification is the coupling of an inviscid algorithm to the viscous method to overcome the nozzle-lip difficulty

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encountered with highly underexpanded nozzles. This modification allowed the relatively easy computation of the interaction resulting from jet-to-free stream static pressure ratios through fifteen. In comparison with the measured data, the predictions of the separation locations are very good through a pressure ratio of 9.2. At a pressure ratio of fifteen, the method underpredicted the extent of separation. GRA

**N85-31007** Cornell Univ., Ithaca, N.Y.  
**FLOATING SHOCK-FITTING IN TRANSONIC POTENTIAL FLOW CALCULATIONS** Ph.D. Thesis  
 F. J. DEJONG 1985 295 p  
 Avail: Univ. Microfilms Order No. DA8504546

In traditional transonic potential flow calculations, shock waves are smeared out over a few mesh cells by the introduction of artificial viscosity terms in the finite difference equation. This approach called shock capturing, requires a very fine mesh in the neighborhood of shocks. A floating shock fitting technique is described, in which shocks are treated as discontinuities: solutions on either side of a shock are matched by jump conditions across the shock. The adjective floating indicates that shock surfaces do not necessarily coincide with mesh surfaces, i.e., shocks float in the mesh. To permit the computation of complex shock configurations in three dimensions, the method employs a very local analysis of each shock. Consistent with a finite volume treatment of flow properties, the properties of a shock that passes through a mesh cell are assumed constant in this cell. An iterative method has to be applied to solve the values of the potential at each mesh point and for the position of each shock.

Dissert. Abstr.

**N85-31008** Societe Nationale Industrielle Aerospatiale, Toulouse (France). Aircraft Div.  
**CALCULATION OF TRANSONIC FLOWS AROUND AN AIRCRAFT CONFIGURATION WITH MOTORIZED NACELLE**  
 Y. VIGNERON and T. LEJAL 18 Feb. 1985 11 p refs  
 Presented at ICAS '84 Conf., 9-14 Sep. 1984  
 (SNIAS-851-111-106) Avail: NTIS HC A01

A numerical method which simulates the transonic flow around an aircraft and its engines is described. The method solves the transonic potential equations by a finite element technique with automatic mesh generation. The nacelle can be either flow-through or powered with specified inlet conditions. In the latter case the plume is solid. Results for an isolated nacelle and for a complete wing-fuselage-nacelle configuration are shown. Author (ESA)

**N85-31010\*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.  
**LOW-SPEED TESTS OF A HIGH-ASPECT-RATIO, SUPERCRITICAL-WING TRANSPORT MODEL EQUIPPED WITH A HIGH-LIFT FLAP SYSTEM IN THE LANGLEY 4-BY 7-METER AND AMES 12-FOOT PRESSURE TUNNELS**  
 H. L. MORGAN, JR. and S. O. KJELGAARD Jul. 1983 277 p refs  
 (NASA-TP-2097; L-15484; NAS 1.60:2097) Avail: NTIS HC A12/MF A01 CSCL 01A

The Ames 12-Foot Pressure Tunnel was used to determine the effects of Reynolds number on the static longitudinal aerodynamic characteristics of an advanced, high-aspect-ratio, supercritical wing transport model equipped with a full span, leading edge slat and part span, double slotted, trailing edge flaps. The model had a wing span of 7.5 ft and was tested through a free stream Reynolds number range from  $1.3 \times 10^6$  to  $6.0 \times 10^6$  per foot at a Mach number of 0.20. Prior to the Ames tests, an investigation was also conducted in the Langley 4 by 7 Meter Tunnel at a Reynolds number of  $1.3 \times 10^6$  to 6th power per foot with the model mounted on an Ames strut support system and on the Langley sting support system to determine strut interference corrections. The data obtained from the Langley tests were also used to compare the aerodynamic characteristics of the rather stiff, 7.5-ft-span steel wing model tested during this investigation and the larger, and rather flexible, 12-ft-span aluminum-wing model tested during a previous investigation. During the tests in both the

Langley and Ames tunnels, the model was tested with six basic wing configurations: (1) cruise; (2) climb (slats only extended); (3) 15 deg take-off flaps; (4) 30 deg take-off flaps; (5) 45 deg landing flaps; and (6) 60 deg landing flaps. F.M.R.

**N85-31011\*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.  
**COMPUTER PROGRAMS FOR SMOOTHING AND SCALING AIRFOIL COORDINATES**  
 H. L. MORGAN, JR. Jul. 1983 187 p refs  
 (NASA-TM-84666; NAS 1.15:84666) Avail: NTIS HC A09/MF A01 CSCL 01A

Detailed descriptions are given of the theoretical methods and associated computer codes of a program to smooth and a program to scale arbitrary airfoil coordinates. The smoothing program utilizes both least-squares polynomial and least-squares cubic spline techniques to smooth iteratively the second derivatives of the y-axis airfoil coordinates with respect to a transformed x-axis system which unwraps the airfoil and stretches the nose and trailing-edge regions. The corresponding smooth airfoil coordinates are then determined by solving a tridiagonal matrix of simultaneous cubic-spline equations relating the y-axis coordinates and their corresponding second derivatives. A technique for computing the camber and thickness distribution of the smoothed airfoil is also discussed. The scaling program can then be used to scale the thickness distribution generated by the smoothing program to a specific maximum thickness which is then combined with the camber distribution to obtain the final scaled airfoil contour. Computer listings of the smoothing and scaling programs are included. B.W.

**N85-31012\*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.  
**TRANSONIC CALCULATIONS FOR A FLEXIBLE SUPERCRITICAL WING AND COMPARISON WITH EXPERIMENT**  
 R. M. BENNETT, D. A. SEIDEL, and M. C. SANDFORD May 1985 19 p refs  
 Presented at the AIAA/ASME/ASCE/AHS 26th Struct., Struct. Dyn. and Mater. Conf., Orlando, Fla., 15-17 Apr. 1985  
 Previously announced in IAA as A85-30407  
 (NASA-TM-86439; NAS 1.15:86439; AIAA-PAPER-85-0665-CP)  
 Avail: NTIS HC A02/MF A01 CSCL 01A

Pressure data measured on the flexible DAST ARW-2 wing are compared with results calculated using the transonic small perturbation code XTRAN3S. A brief description of the analysis is given and a recently-developed grid coordinate transformation is described. Calculations are presented for the rigid and flexible wing for Mach numbers from 0.60 to 0.90 and dynamic pressures from 0 to 1000 psf. Calculated and measured static pressures and wing deflections are compared, and calculated static aeroelastic trends are given. Attempts to calculate the transonic instability boundary of the wing are described. Author

**N85-31013\*** Vigyan Research Associates, Inc., Hampton, Va.  
**AN EXPERIMENTAL INVESTIGATION OF PROPFAN INSTALLATIONS ON AN UPSWEPT SUPERCRITICAL WING AT TRANSONIC MACH NUMBERS** Final Report, 1 Aug. 1983 - 1 May 1985  
 G. R. BARTLETT May 1985 208 p refs  
 (Contract NAS1-17826)  
 (NASA-CR-172605; NAS 1.26:172605) Avail: NTIS HC A10/MF A01 CSCL 01A

An investigation has been conducted in the Langley 16 Foot Transonic Tunnel to determine propfan installation and slipstream interference effects on an unswept supercritical wing. This data can be used for verification of existing and developing theoretical codes as well as giving an understanding of the flow interactions associated with propeller/nacelle/wing integration. The investigation was conducted over a Mach number range of 0.5 to 0.8 and at angles of attack from 0 deg to 3 deg. The propeller was powered by an air turbine simulator and the exhaust from the air turbine was used to simulate the exhaust from the propfan nacelle. Reynolds number based on wing chord varied from 3 to

4 million. Results indicate that the propfan causes an increase in the wing lift coefficient. It was found that most of the propeller induced swirl is recovered by the wing. The propeller slipstream also causes a large favorable leading edge suction peak on the upwash side and a smaller unfavorable decrease on the downwash side.

Author

**N85-31014\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.  
**EFFECT OF GROUND AND/OR CEILING PLANES ON THRUST OF ROTORS IN HOVER**

V. J. ROSSOW Jul. 1985 41 p refs  
(NASA-TM-86754; REPT-85256; NAS 1.15:86754) Avail: NTIS HC A03/MF A01 CSCL 01A

The thrust produced by a helicopter rotor hovering near ground and/or ceiling planes is investigated experimentally and theoretically. In the experiment, the thrust was measured on a 0.324-m-diam rotor operating between floor and ceiling planes which were located from 6 to 0.08 diam from the rotor disk. In the first theoretical model studied, the incompressible and inviscid flow induced by a sequence of vortex cylinders, located above and below the rotor to simulate the rotor wake and its interaction with the floor and ceiling planes, was considered. Comparison with experiment showed that this model overpredicts the change in thrust caused by the proximity of the walls. Therefore, a second arrangement of vortex cylinders was introduced which provides a more accurate prediction of the ground and ceiling effects on the thrust of the rotor in hover. The applicability of these results to a vented wind tunnel is also discussed.

Author

**N85-31015\*#** Boeing Vertol Co., Philadelphia, Pa.  
**FUSELAGE UPWASH EFFECTS ON RSRA ROTOR SYSTEMS**

J. COWAN and L. DADONE Aug. 1985 256 p  
(Contract NAS2-11307)  
(NASA-CR-177349; NAS 1.26:177349; D210-12359-1) Avail: NTIS HC A12/MF A01 CSCL 01A

The effects of RSRA fuselage configurations on rotor performance and loads have been quantified analytically by means of currently available potential flow and rotor analysis. Four configurations of the Rotor Systems Research Aircraft (RSRA) were considered in this study. They were: (1) fuselage alone (conventional helicopter); (2) fuselage with auxiliary propulsion; (3) fuselage with wings (auxiliary lift); and (4) fuselage with both auxiliary lift propulsion. The rotor system investigated was identical to a CH-47D front rotor except that it had four instead of three blades. Two scaled-down versions of the same rotor were also analyzed to determine the effect of rotor scale on the fuselage upwash effects. The flight conditions considered for the upwash study are discussed. The potential flow models for the RSRA configuration, with and without the wings and the auxiliary propulsion system, are presented. The results of fuselage/wing/propulsion system upwash on performance and loads are also presented.

B.W.

**N85-31017#** Office National d'Etudes et de Recherches Aérospatiales, Paris (France). Direction Scientifique de la Résistance des Structures.

**EXTENSION OF THE SMALL PERTURBATIONS METHOD IN THREE-DIMENSIONAL TRANSONIC, UNSTEADY FLOW TO THE CASE OF REAL WINGS** Final Report [EXTENSION DE LA METHODE DES PETITES PERTURBATIONS TRANSSONNIQUES INSTATIONNAIRES TRIDIMENSIONNELLES AU CAS DES VOILURES REELLES]

P. MULAK Feb. 1984 35 p refs In FRENCH  
(Contract DRET-83-34-135)

(ONERA-NT-17/3064-RY-070-R) Avail: NTIS HC A03/MF A01

A two dimensional method for cylindrical wings is extended to arbitrary projected shape wings which may have different wing profiles along the length. The computation is demonstrated for a supercritical wing and a short wing with high camber. The computation times obtained on a CRAY-1 computer and accuracy are satisfactory.

Author (ESA)

**N85-31018#** Office National d'Etudes et de Recherches Aérospatiales, Paris (France). Direction des Grands Moyens d'Essais.

**REAL SCALE TEST OF THE PETIT CANARD AIRCRAFT IN THE NUMBER 3 SECTION, 47 SQM, OF THE SIMA WIND TUNNEL, MAY 1984 [ESSAIS DE L'AVION PETIT CANARD REEL DANS LA VEINE 3-47 M2 DE LA SOUFFLERIE SIMA, MAI 1984]**

R. DESTUYNDER and R. SELVAGGINI Jun. 1984 81 p In FRENCH

(Contract DRET-83-34-369)

(ONERA-PV-1/0772-GY) Avail: NTIS HC A05/MF A01

Wind tunnel tests on a 5.2 m long aircraft were carried out at velocities from 55 to 175 m/sec (Mach 0.5) measuring the aerodynamic characteristics in a wide range set of flight parameters. The aircraft is powered by 2 microturbo TRS 18 jets. Hysteresis phenomena are detected. After modifying the aerodynamic configuration no instability is apparent.

Author (ESA)

**N85-31019#** Office National d'Etudes et de Recherches Aérospatiales, Paris (France). Direction des Grands Moyens d'Essais.

**AERODYNAMIC MEASUREMENT OF THE WIND FLOW IN THE NUMBER TWO SECTION OF THE SIMA WIND TUNNEL [MESURES D'ASCENDANCE ET DE DERAPAGE DANS LA VEINE NO. 2 DE SIMA]**

A. GIACCHETTO Nov. 1984 24 p In FRENCH

(Contract STPA-84-95-014)

(ONERA-PV-1/8138-GY) Avail: NTIS HC A02/MF A01

The orientation of the velocity vector in the positions occupied by the models in ground effect studies is analyzed. An angular variation of several tenths of degree is found, probably due to wall effects, and which could be compensated by wall modifications. The influence of the model mast is also discussed.

Author (ESA)

**N85-31020#** Aeronautical Research Inst. of Sweden, Stockholm. Aerodynamics Dept.

**TRANSONIC AND SUPERSONIC WIND TUNNEL TESTS ON CONTROL EFFECTIVENESS ON SCHEMATIC MISSILE CONFIGURATIONS**

S. E. GUNDMUNDSON and L. TORNGREN Dec. 1983 238 p refs

(Contract FMV-FLYGFL-82223-73-009-07-001;

FMV-FLYGFL-82223-75-007-07-001;

FMV-FLYGFL-82223-76-001-21-001)

(FFA-TN-1983-20) Avail: NTIS HC A11/MF A01

Pitch control effectiveness at transonic and supersonic speeds for two body-tail and two wing-body-tail missile configurations was investigated in wind tunnels. At 0 roll angle position the setting angles of the 2 horizontal controls were varied from 0 to -20 deg in 5 deg steps. At 45 deg roll angle position all 4 controls were fixed at the same setting angles. For 1 of the body-tail and for both wing-body-tail missile configurations, roll control effectiveness at 0 and 45 deg roll position was investigated. All tail controls were set in 5 or 10 deg setting for producing rolling moment in the same roll direction. A combined pitch and roll control setting was also tested at the two roll positions. The test results were used to evaluate average values for the flow direction (downwash or upwash) at the rear end of the models at different speeds and angles of attack.

Author (ESA)

**N85-31021#** Aeronautical Research Inst. of Sweden, Stockholm. Aerodynamics Dept.

**TRANSONIC AND SUPERSONIC WIND TUNNEL TESTS ON CONTROL EFFECTIVENESS ON SCHEMATIC MISSILE CONFIGURATIONS: SUPPLEMENT**

S. E. GUNDMUNDSON and L. TORNGREN 1983 144 p

(FFA-TN-1983-20-SUPPL) Avail: NTIS HC A07/MF A01

Pitch control effectiveness two body-tail and two wing-body-tail missile configurations was studied in wind tunnels. At 0 roll angle position the setting angles of the 2 horizontal controls differed from 0 to -20 deg in 5 deg steps. At 45 deg roll angle position all



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4 controls were fixed at the same setting angles. For 1 of the body-tail and for both wing-body-tail missile configurations, roll control effectiveness at 0 and 45 deg roll position was investigated. All tail controls were set in 5 or 10 deg settings for producing rolling moment in the same roll direction. A combined pitch and roll control setting was also tested at the two roll positions. The test results were used to evaluate average values for the flow direction (downwash or upwash) at the rear end of the models at various speeds and angles of attack. Author (ESA)

**N85-31022#** Aeronautical Research Inst. of Sweden, Stockholm. Aerodynamics Dept.

### **CALCULATION OF FLOW AROUND THE SF 310 AIRPLANE USING A FULL POTENTIAL EQUATION METHOD**

S. G. HEDMAN Nov. 1984 17 p refs

(Contract STU-81-4626B)

(FFA-TN-1984-63) Avail: NTIS HC A02/MF A01

The wing pressure distributions of an SF340 airplane with slightly modified geometry were calculated at small incidences for Mach numbers between 0.15 and 0.75 with a full potential finite volume program. It is an exact numerical method for solving subsonic and transonic potential flow around wing-body configurations. Flow behavior up to high Mach numbers was estimated. Computed wing pressures agree well with values obtained at low Mach numbers in a wind tunnel. It is found that the approximated SF340 at  $\alpha = 18$  deg has a completely subsonic flow up to Mach number 0.6. There is an acceptable agreement in the growth of the compressibility drag. Author (ESA)

**N85-31024#** Technische Hogeschool, Delft (Netherlands). Dept. of Aerospace Engineering

### **A THEORY OF QUASI-CONICAL SOLUTIONS OF NONINTEGER DEGREE**

H. J. BOS Feb. 1984 46 p refs

(UTH-LR-420) Avail: NTIS HC A03/MF A01

Based on a generalized concept of a derivative, the theory of quasi-conical flow fields of integer degree is extended to quasi-conical solutions of the Prandtl-Glauert equation of noninteger degree. Symmetrical but odd terms in the spanwise coordinate are added to the downwash field. The singular integral equation for the load distribution on the wing is reproduced. A generalized concept of a derivative is introduced and a modified form of the singular integral equation for the load distribution is shown to apply in this case. Author (ESA)

**N85-31026#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Goettingen (West Germany). Inst. fuer Aeroelastik.

### **A SUPERSONIC POTENTIAL GRADIENT METHOD FOR THE CALCULATION OF UNSTEADY AERODYNAMIC PRESSURES ON HARMONICALLY OSCILLATING WINGS Ph.D. Thesis - Technische Hochschule**

F. ZHANG Feb. 1985 107 p refs In GERMAN; ENGLISH summary Report will also be announced as translation (ESA-TT-930)

(DFVLR-FB-85-11; ISSN-0171-1342) Avail: NTIS HC A06/MF A01; DFVLR, Cologne DM 35

A method for calculating unsteady aerodynamic pressure distribution on harmonically oscillating three-dimensional wings in supersonic flow based on the velocity potential, the Jones-Appa gradient method and the application of an integral variable substitution to evaluate the aerodynamic influence functions was developed. The method simplifies the computation and reduces computing time at low supersonic Mach numbers and high reduced frequencies. Investigations on typical wing configurations confirm accuracy. Author (ESA)

**N85-31027#** National Aerospace Lab., Amsterdam (Netherlands). Fluid Dynamics Div.

### **VERIFICATION OF CALCULATION METHODS FOR UNSTEADY AIRLOADS IN THE PRECIPITATION OF TRANSONIC FLUTTER**

R. J. ZWAAN 24 Feb. 1984 11 p refs Presented at AIAA/ASME/ASCE/AHS 25 Struct., Struct. Dyn. and Mater. Conf., Palm Springs, Calif., 14-16 May 1984

(Contract NIVR-1889; NIVR-1890; RB-RLD-1983:1.2/LW)

(NLR-MP-84016-U; B8562384) Avail: NTIS HC A02/MF A01

Engineering methods to calculate unsteady airloads on wings in transonic flow were applied in flutter calculations for a semispan flutter model of a supercritical wing. A verification was performed by comparing flutter characteristics, and the prediction of transonic dips in the flutter boundaries. When applied complementarily, the methods produce useful results. Author (ESA)

**N85-31028#** Advisory Group for Aerospace Research and Development, Neuilly-Sur-Seine (France).

### **COMPENDIUM OF UNSTEADY AERODYNAMIC MEASUREMENTS, ADDENDUM 1**

Loughton, England May 1985 127 p refs Supplement to AGARD-R-702; see N83-14065

(AGARD-R-702-ADD-1; ISBN-92-835-1495-5) Avail: NTIS HC A07/MF A01

Data sets of wind tunnel measurements made on aeroelastic configurations are given. Data are given on the ZKP wing with an oscillating aileron and on the LANN wing pitching oscillations.

**N85-31029#** Messerschmitt-Boelkow-Blohm G.m.b.H., Bremen (West Germany). Transport und Verkehrsflugzeuge.

### **DATA SET 8: ZKP WING, OSCILLATING AILERON**

K. DAU, S. VOGEL, and H. ZIMMERMANN in AGARD Compendium of Unsteady Aerodynamic Meas., Add. 1 44 p May 1985 refs

Avail: NTIS HC A07/MF A01

A data set containing pressure distributions measured on the ZKP wing for an oscillating aileron in the ONERA transonic S1 wind tunnel at Modane, France, in late 1982 is given. The purpose of the tests was to obtain steady and unsteady pressures due to fast-moving control surfaces in transonic flow, likely to be encountered in the operation of active control systems for transport aircraft. R.J.F.

**N85-31030#** National Aerospace Lab., Amsterdam (Netherlands). Aeroelasticity Dept.

### **DATA SET 9: LANN WING. PITCHING OSCILLATION**

R. J. ZWAAN In AGARD Compendium of Unsteady Aerodynamic Meas., Add. 1 76 p May 1985 refs

Avail: NTIS HC A07/MF A01

This data set relates to a semi-span model of a transport-type wing with a supercritical aerofoil from root to tip. One of the objectives of this program was to create an experimental data base for steady and unsteady transonic computer code evaluation. The wing geometry was designed by Lockheed-Georgia, where the wing became known as wing A. A smaller scale model was already tested in steady flow. The mean test conditions are shown. In view of the intended correlations of experimental and calculated data, the greater part of the test runs was carried out with attached flow. Examples of the mean steady and the unsteady pressure distributions are given as well as spanwise load distributions. As all test runs were made at more or less different conditions, a modified set of CT cases is proposed in this data set. The modifications, however, leave the kind of parameter variations as foreseen in the original set of Ref. 9.4 practically unchanged. From the correlation of experimental and calculated data, it appears that the correlation can be made most appropriately for the pressure distributions. The correlation of sectional coefficients is hampered by less accurate experimental values caused by a number of failing pressure tubes in regions of strong pressure gradients. R.J.F.

**N85-32023#** National Aeronautical Lab., Bangalore (India).  
**R AND D ACTIVITIES OF THE AERODYNAMICS DIVISION**  
 M. A. RAMASWAMY *In its R and D Programmes at the Natl. Aeron. Lab.* p 1-26 1983 refs  
 Avail: NTIS HC A10/MF A01

Research and development activities at the National Aeronautical Laboratory in India are discussed. Aircraft aerodynamics, unsteady aerodynamics, fluid mechanics, and computer aided design research efforts are described. R.J.F.

## 03

## AIR TRANSPORTATION AND SAFETY

Includes passenger and cargo air transport operations; and aircraft accidents.

**A85-41053#**  
**DID SAFE JET FUEL FLUNK ITS FINAL EXAM?**

R. DEMEIS *Aerospace America* (ISSN 0740-722X), vol. 23, July 1985, p. 46-49.

A critical discussion is presented concerning analytical results obtained to date for the recent full-scale test of the antimisting jet fuel additive FM-9. The test, which simulated the crash of a B 720 jet airliner with a full load of passengers, led upon impact to a fireball and catastrophic fire. It has been determined that degraded engine fuel, together with oil and hydraulic fluid, bathed the hot engine case and were ignited by hot combustion gases. Although the passenger-simulating dummies in the cabin 'survived' impact, the cabin was consumed by fire. Crash test data are still being evaluated. O.C.

**A85-41065**  
**ICING ON AIRCRAFT - AGAIN A TOPIC OF INTEREST**  
**[VEREISUNG AN LUFTFAHRZEUGEN - WIEDER AKTUELL GEWORDEN]**

H.-E. HOFFMAN (DFVLR, Institut fuer Physik der Atmosphaere, Oberpfaffenhofen, West Germany) *DFVLR-Nachrichten* (ISSN 0011-4901), June 1985, p. 24-28. In German. refs

Current research on the formation of ice on aircraft surfaces, being undertaken in the US, Canada, and West Germany in cooperation with the DFVLR, is surveyed and illustrated with graphs, tables, satellite images of ice-forming weather patterns, and photographs of measurement apparatus. The aims of the research program include determination of operational restrictions on the basis of meteorological parameters, improvement of forecasting of icing conditions on the basis of specific criteria, evaluation of theoretical models of ice formation, and development of accurate instruments to measure cloud parameters in situ. T.K.

**A85-41337#**  
**COMMUTER AIRLINES - THE MANUFACTURER'S VIEWPOINT**  
 M. C. W. DAVY (De Havilland Aircraft of Canada, Ltd., Downsview) *AIAA, ASCE, TRB, and CASI, International Air Transportation Conference, Norfolk, VA, June 26-28, 1985, Paper. 7 p.*

Market, safety and efficiency demands placed on a manufacturer supplying fixed-wing aircraft for use in commuter operations are discussed. The continual push for larger routes implies flights requiring meal service and an associated elimination of propeller-driven aircraft in favor of jets. The addition of an auxiliary power unit eliminates ground crew costs in hub-and-spoke airports. Furthermore, the buyer frequently wishes the aircraft to have a small minimum requirements list for certification to permit continued operation in the face of component failures. It is recommended that aircraft be built for changing markets and be strongly advertised. The manufacturer will need a dependable field support system to compensate for the reluctance of entrepreneurs to maintain a comprehensive inventory of parts. Finally, it is believed

that all-weather rating will become necessary in the future.

M.S.K.

**A85-41726**  
**ANALYSIS OF FLIGHT-RECORDED DATA AS A CONTRIBUTION TO SAFETY IN AIR OPERATIONS**

P. H. D. HAYES and E. WHITE (Flight Data Co., Ltd., Longford, England) *International Journal of Aviation Safety* (ISSN 0264-6803), vol. 3, June 1985, p. 96-100.

Attention is given to the opportunities offered by the availability of commercial aircraft flight recorder digital data for air safety-related analytical determinations. Such determinations are noted to be of paramount value in the assessment of autopilot system behavior and engine health monitoring, with a view to incipient failures' early detection. More generally, studies can be made of the factors associated with incidents which may have led to serious accidents, in order to formulate alternative procedures which will enhance flight safety. A full flight data recorder replay and analysis system has been developed which can reveal unsuspected relationships among flight parameters and transient histories. O.C.

**A85-41727**  
**INTEGRATING AERONAUTICAL INFORMATION FOR FLIGHT OPERATIONS**

F. W. FISCHER (FSB Flugsicherungssystem-Beratungs-GmbH, Westerngrund, West Germany) *International Journal of Aviation Safety* (ISSN 0264-6803), vol. 3, June 1985, p. 101-105.

The provision of information to air space users in a form that is highly integrated, aiding preflight preparation, flight planning, and updates during flight, is increasingly being undertaken by such highly automated systems as the Computerized Aeronautical Information Data System (CAIDS). CAIDS presents the required information to the civil or military flight preparations operator on one display, and in a form that is preselected, presorted, integrated and conclusive; use is made of color coding, together with symbolic presentations of warnings, updates, and changes. O.C.

**A85-41729**  
**ROUTES TO IMPROVED AIRWORTHINESS OF HELICOPTERS**

R. S. ELWELL (Psychavia, Ltd., England) *International Journal of Aviation Safety* (ISSN 0264-6803), vol. 3, June 1985, p. 114-117. refs

In recent years, the intensive use of helicopters over the North Sea in support of oil extraction operations has led to several accidents whose study by a British review panel led to a number of recommendations. Attention is presently given to this Helicopter Airworthiness Review Panel's thrust and the tenor of subsequent comments on its findings. Relevant topics encompass safety factors in damage-tolerant helicopter airframe structures, the fatigue strength of metallic components, fatigue load spectra, the economic impact of enhanced safety features, crashworthiness and survivability criteria incorporated in military helicopter design, and helicopter forced landings at sea. O.C.

**A85-41731**  
**BUSH AVIATION - HOW EFFECTIVE ARE PRESENT REGULATIONS?**

P. RIVEST (Department of Transport Air Service, Ancienne Lorette, Canada) *International Journal of Aviation Safety* (ISSN 0264-6803), vol. 3, June 1985, p. 131-135.

The regulatory requirements of bush aviation and their economic effects are discussed for the case of bush operations in Canada, which account for 90 percent of accidents involving commercial aircraft in that country. Technical regulation for bush aviation must take into account the climatic and topographical conditions of various geographic regions, in addition to the more usual matters regarding personnel, airport and traffic control infrastructure, and equipment airworthiness. O.C.

### 03 AIR TRANSPORTATION AND SAFETY

**A85-41732**

**PREVENTING INFRINGEMENTS OF RESTRICTED AIRSPACE**

H. M. VERMEULEN International Journal of Aviation Safety (ISSN 0264-6803), vol. 3, June 1985, p. 136-138.

The current procedures for interception of foreign aircraft in cases of territorial airspace infringements are discussed with a view to their shortcomings, and alternative procedures are recommended. Attention is given to the North Pacific route structure between Anchorage, Alaska, and Seoul, South Korea, where aids for successful navigation are notably deficient, and over which the application of questionable interception criteria led to the destruction of a B 747 airliner by Soviet fighters on the night of August 31, 1983.

O.C.

**A85-41733**

**NEW ICAO PROCEDURES ON INSTRUMENT DEPARTURES AND NOISE ABATEMENT**

J. BOOM International Journal of Aviation Safety (ISSN 0264-6803), vol. 3, June 1985, p. 139-144.

The recent determinations made by the International Civil Aviation Administration (ICAO) on instrument departures, which cover safe obstacle clearance after takeoff, and noise abatement, which involves aircraft avoidance of overflights of noise-sensitive areas during initial climb-outs and final approaches. In this latter case, the ICAO stresses the primacy of safety considerations which allow a pilot to ignore all noise abatement-related restrictions in the interest of obstacle and collision avoidance.

O.C.

**A85-42065**

**A REVIEW OF ARMY AIR CORPS HELICOPTER ACCIDENTS 1971-1982**

P. VYRNWY-JONES (RAF, Institute of Aviation Medicine, Farnborough, England) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 56, May 1985, p. 403-409. refs

A comprehensive review of helicopter accident data from AAC sources is presented for the period 1971-1982. Accident and fatality rates have declined from the high values quoted in earlier studies in the 1960's and are now similar to those of fixed wing aircraft equipped with ejection seats. This improvement is related to the replacement of older reciprocating engined helicopters by turbine powered units and parallel progress in helicopter design, aircraft servicing, and pilot training. AAC accident rates now compare extremely favourably with information from civilian sources, though fatality rates are similar. Pilot error remains the main cause of accidents (75 percent). Particular attention is paid to subsidiary aetiologies such as tail rotor strikes, disorientation, and ground accidents. Helicopter accidents involving fatalities on Operation Corporate are mentioned briefly. Methods whereby occupant protection and aircraft crashworthiness can be improved are covered and it is concluded that assisted escape, although an ideal solution, is by no means an urgent requirement for helicopters, in view of the dramatic reduction in accident and fatality rates.

Author

**A85-42074**

**THE AIRLINE PASSENGER UNDERGOING WITHDRAWAL OR OVERDOSE FROM NARCOTICS OR OTHER DRUGS**

J. L. LYMAN and S. R. MOHLER (Wright State University, Dayton, OH) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 56, May 1985, p. 451-456. refs

The symptoms and treatment of drug overdose and withdrawal are discussed in a general review intended for the instruction of flight attendants. Categories of drugs considered include opiates, amphetamines, cocaine, CNS depressants, marijuana, phencyclidine, LSD, and mescaline/peyote. More extensive training in the recognition of these conditions, a firm and calm approach to handling the affected passenger, and the inclusion of antagonists or therapeutic drugs (for administration by qualified personnel or physician passengers) in onboard medical kits are recommended.

T.K.

**A85-42075**

**THE CINCINNATI DC-9 EXPERIENCE - LESSONS IN AIRCRAFT AND AIRPORT SAFETY**

G. A. PANE, S. R. MOHLER, and G. C. HAMILTON (Wright State University, Dayton, OH) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 56, May 1985, p. 457-461. refs

The 23-fatality crash of a DC-9 at Cincinnati on June 2, 1983 and its implications for aircraft and airport safety procedures and equipment for dealing with in-flight fires are discussed, summarizing the findings of NTSB reports. The emphasis is on the important role of poisonous-fume inhalation in the fatalities and on delays in passenger evacuation due to disorientation and panic. Recommendations based on the study of this accident include the provision of septal-seal smoke hoods for passengers, improved aisle lighting at floor level, better smoke goggles or masks for crew, the use of advanced plastics in aircraft construction to minimize toxic-fume production, thorough training and drills for airport and surrounding-jurisdiction emergency personnel, and installation of lavatory smoke detectors and additional onboard fire extinguishers.

T.K.

**A85-42089**

**FOOD POISONING AS AN IN-FLIGHT SAFETY HAZARD**

K. N. BEERS and S. R. MOHLER (Wright State University, Dayton, OH) Aviation, Space, and Environmental Medicine (ISSN 0095-6562), vol. 56, June 1985, p. 594-597. refs

The incapacitation of commercial pilots by food-induced gastrointestinal illness is discussed, reviewing statistical data for the period 1961-1976. The pathogens involved, signs and symptoms, geographic factors, flight kitchens as primary source of infection, and the current lack of regulations regarding crew meals are considered. Preventive measures (food-selection and food-preparation techniques and careful eating habits) are suggested, therapeutic measures are recommended, and specific regulations on aircrew feeding are proposed for FAA consideration.

T.K.

**A85-42937\*#** Texas A&M Univ., College Station.

**PERFORMANCE DEGRADATION OF HELICOPTER ROTOR IN FORWARD FLIGHT DUE TO ICE**

K. D. KORKAN (Texas A & M University, College Station), L. DADONE (Boeing Vertol Co., Philadelphia, PA), and R. J. SHAW (NASA, Lewis Research Center, Cleveland, OH) Journal of Aircraft (ISSN 0021-8669), vol. 22, Aug. 1985, p. 713-718. refs (Contract NAG3-242)

This study addresses the analytical assessment of the degradation in the forward flight performance of the front rotor Boeing Vertol CH47D helicopter in a rime ice natural icing encounter. The front rotor disk was divided into 24 15-deg sections and the local Mach number and angle of attack were evaluated as a function of azimuthal and radial location for a specified flight condition. Profile drag increments were then calculated as a function of azimuthal and radial position for different times of exposure to icing, and the rotor performance was re-evaluated including these drag increments. The results of the analytical prediction method, such as horsepower required to maintain a specific flight condition, as a function of icing time have been generated. The method to illustrate the value of such an approach in assessing performance changes experienced by a helicopter rotor as a result of rime ice accretion is described.

Author

**A85-42938#**

**RECONSTRUCTION OF PAN AM ORLEANS ACCIDENT**

M. A. DIETENBERGER, P. A. HAINES, and J. K. LUERS (Dayton, University, OH) Journal of Aircraft (ISSN 0021-8669), vol. 22, Aug. 1985, p. 719-728. refs

An improved technique has been developed for reconstructing the trajectory of an aircraft based upon the analysis of five channel flight data recorder (FDR) information. The FDR data of heading, indicated airspeed, pressure altitude, and load factor are combined with engine thrust, aircraft aerodynamic data, and the boundary conditions for the trajectory in order to solve the lift and drag equations of the aircraft. In reconstructing aircraft wind shear

accidents, the trajectory of the aircraft, the horizontal wind field, and pitch time history of the aircraft can be determined uniquely. If factors other than wind shear are present that may potentially influence aircraft aerodynamic performance, such as wing ice or rain induced aerodynamic roughness, then both wind shear and roughness penalties can be calculated by imposing additional constraints on the trajectory. The reconstruction technique has been applied to the Pan Am accident in New Orleans July 1982 in which both wind shear and heavy rain were present. Three scenarios were considered - wind shear only, aerodynamic penalties due to heavy rain only, and a combination of wind shear and lift loss and drag increase due to heavy rain. It is suggested that the latter scenario gives results that are most consistent with other evidence concerning the accident. Author

**N85-29936** Department of the Navy, Washington, D. C.  
**AIR BAG RESTRAINT SYSTEM Patent**  
D. L. LORCH, inventor (to Navy) 2 Apr. 1985 6 p Supersedes AD-D010486  
(AD-D011671; US-PATENT-4,508,294;  
US-PATENT-APPL-SN-490827; US-PATENT-CLASS-244-122)  
Avail: US Patent and Trademark Office CSCL 01B

An air bag restraint system is disclosed for protecting an occupant in a seat during ejection from a vehicle, particularly an aircraft. In one preferred embodiment, an air bag member is deployed from a stored position frontally to the chest of the occupant and guided upward and downward along tracks on either side of the seat so that the upper body of the occupant is enclosed within the seat just prior to ejection. In another preferred embodiment, the air bag is stowed within a cover about a semi-circular hoop releasably connected to the seat about the chest of the occupant. At the initiation of the ejection sequence, the cover is released and the air bag inflated, expanded into the proper shape by external restraint straps, so that the head, arms and torso of the occupant are encapsulated at the time of ejection. GRA

**N85-29937\*** Miami Univ., Coral Gables, Fla. Dept. of Management Science.  
**HUMAN FACTORS IN COCKPIT AUTOMATION: A FIELD STUDY OF FLIGHT CREW TRANSITION**  
E. L. WIENER Jul. 1985 124 p refs  
(Contract NCC2-152)  
(NASA-CR-177333; NAS 1.26:177333) Avail: NTIS HC A06/MF A01 CSCL 05H

The factors which affected two groups of airline pilots in the transition from traditional airline cockpits to a highly automated version were studied. All pilots were highly experienced in traditional models of the McDonnell-Douglas DC-9 prior to their transition to the more automated DC-9-80. Specific features of the new aircraft, particularly the digital flight guidance system (DFGS) and other automatic features such as the autothrottle system (ATS), autobrake, and digital display were studied. Particular attention was paid to the first 200 hours of line flying experience in the new aircraft, and the difficulties that some pilots found in adapting to the new systems during this initial operating period. Efforts to prevent skill loss from automation, training methods, traditional human factors issues, and general views of the pilots toward cockpit automation are discussed. E.A.K.

**N85-29938#** National Transportation Safety Board, Washington, D. C. Bureau of Technology.  
**GENERAL AVIATION CRASHWORTHINESS PROJECT. PHASE 2: IMPACT SEVERITY AND POTENTIAL INJURY PREVENTION IN GENERAL AVIATION ACCIDENTS**  
15 Mar. 1985 46 p  
(PB85-917002; NTSB-SR-85-01) Avail: NTIS HC A03/MF A01 CSCL 01C

The purpose of the general aviation crashworthiness program is to provide information to support changes in crashworthiness design standards for seating and restraint systems in general aviation airplanes. Specific data on survivable accidents are presented. The data suggest that the survivable envelope is defined

by impact speeds of 45 knots at 90 degrees of impact angle, 60 knots at 45 degrees, and 75 knots at zero degrees. Data are presented which demonstrate that if all occupants wear shoulder harnesses, fatalities are expected to be reduced by 20% and 88% of the seriously injured persons in survivable crashes are expected to experience significantly fewer life threatening injuries. Thirty-four percent of the seriously injured occupants of survivable accidents are expected to be less seriously injured if energy absorbing seats are available. E.A.K.

**N85-29939#** Notre Dame Univ., Ind. Dept. of Aerospace and Mechanical Engineering.  
**NUMERICAL SIMULATIONS OF THE EFFECT OF FLOOR AND CEILING VENTING ON FIRE AND SMOKE SPREAD IN AIRCRAFT CABINS**  
B. P. DESOUZA, K. T. YANG, and J. R. LLOYD Dec. 1984 72 p refs  
(Contract NB81-NADA-2000)  
(PB85-178333; NBS-GCR-84-479) Avail: NTIS HC A04/MF A01 CSCL 01B

The effects of fires on the interior environment of an aircraft were studied. Fires both internal and external to the aircraft were considered. The thrust of the work was to obtain the interior flow field. The flow was calculated using two- and three-dimensional field models with experimental verification in a wind tunnel. GRA

**N85-31031#** Simula, Inc., Tempe, Ariz.  
**ANALYSIS OF ROTORCRAFT CRASH DYNAMICS FOR DEVELOPMENT OF IMPROVED CRASHWORTHINESS DESIGN CRITERIA Final Report, Mar. 1981 - May 1985**  
J. W. COLTMAN, A. O. BOLUKBASI, and D. H. LAANANEN Jun. 1985 191 p refs  
(Contract DTF A03-81-C-00035)  
(FAA/CT-85-11; TR-83414A) Avail: NTIS HC A09/MF A01

A review was conducted of U.S. civil helicopter accidents occurring between 1974 and 1978 to determine impact conditions and injuries to the occupants. The distribution of impact conditions are described. Also, six typical impact scenarios were developed to represent classes of accidents. A rank ordered analysis of crash hazards is presented. An evaluation of computer techniques available for structural crash dynamics simulation is presented along with a comparison of the civil and military helicopter crash environments. Recommended crashworthiness design criteria for civil rotorcraft are presented. Author

**N85-31032#** Committee on Public Works and Transportation (U. S. House).  
**FAA REGULATION OF 9-SEAT AND UNDER PASSENGER AIRCRAFT**  
Washington GPO 1985 199 p refs Hearing before the Subcomm. on Invest. and Oversight of the Comm. on Public Works and Transportation, 98th Congr., 1st Sess., 27 Sep. 1983  
(GPO-42-703) Avail: Subcommittee on Investigations and Oversight

A hearing was conducted and expert testimony heard on the need to adapt more stringent requirements (FAA regulation) to nine seat and under passenger aircraft. G.L.C.

**N85-31033#** Luftfahrt-Bundesamt, Brunswick (West Germany).  
**THIRTY YEARS' ACTIVITIES FOR AIRCRAFT SAFETY [30 JAHRE TAETIGKEIT FUER DIE SICHERHEIT DER LUFTFAHRT]**  
1985 30 p In GERMAN  
Avail: NTIS HC A03/MF A01

Aircraft reliability; quality control; certification; specifications; aircraft equipment; economical performance of airlines; pilot schools; personnel management; air law; airworthiness; and aircraft accident and hazard investigation are discussed. Author (ESA)

### 03 AIR TRANSPORTATION AND SAFETY

**N85-31034#** European Space Agency, Paris (France).

#### **DEFINITION AND LAYOUT OF A TRAFFIC GENERATOR FOR AN AIR TRAFFIC CONTROL SIMULATION**

D. DIPPE and J. THOMAS Jan. 1985 79 p refs Transl. into ENGLISH of "Definition u. Auslegung eines Verkehrsgenerators fuer eine Flugsicherungssimulation" Brunswick, Rept. DFVLR-FB-84-15, 1984 Original language doc. previously announced as N84-29862

(ESA-TT-888; DFVLR-FB-84-15) Avail: NTIS HC A05/MF A01; original German version available from DFVLR, Cologne DM 29

An air traffic generator was developed and implemented as a computer program which produces realistic traffic samples. The concept is based on the analysis of real air traffic control (ATC) structures and traffic flows. In a Monte Carlo traffic generation process, statistically varied traffic samples are computed as a function of user selectable characteristics of a given scenario. The resultant flight plans and initial states for individual aircraft are directly used to drive a real time ATC simulation. The computation process is illustrated for a typical application.

Author (ESA)

## 04

### AIRCRAFT COMMUNICATIONS AND NAVIGATION

Includes digital and voice communication with aircraft; air navigation systems (satellite and ground based); and air traffic control.

**A85-40243**

#### **RADIO NAVIGATION AND LANDING DEVICES FOR IFR NAVIGATION WITH HELICOPTERS [FUNKNAVIGATIONS- UND LANDEHILFEN FUER IFR-BETRIEB MIT HUBSCHRAUBERN]**

E. SCHLEMPER (Standard Elektrik Lorenz AG, Stuttgart, West Germany) Ortung und Navigation (ISSN 0474-7550), vol. 26, no. 1, 1985, p. 75-89. In German.

Helicopter navigation and landing systems are discussed. Operational demands on helicopters are addressed, and the characteristics of different positioning systems are compared. Helideck landing is discussed, and the use of the DPS and GPS systems for navigation and landing by helicopter is examined.

C.D.

**A85-40292#**

#### **STATUS AND DEVELOPMENT TRENDS OF NAVIGATION SYSTEMS FOR GENERAL AVIATION [STAND UND ENTWICKLUNGSTENDENZEN VON NAVIGATIONSSYSTEMEN FUER DIE ALLGEMEINE LUFTFAHRT]**

K. HURRASS (DFVLR, Institut fuer Flugfuehrung, Brunswick, West Germany) DGLR and DGON, Symposium ueber die allgemeine Luftfahrt und Regional Luftverkehr-Bestandteile des Verkehrssystems, Friedrichshafen, West Germany, Mar. 26-29, 1985, Paper. 23 p. In German. refs

Current navigation systems for use by general-aviation aircraft are surveyed, and improvements planned for the coming decades are characterized. Consideration is given to VOR/DME, nondirectional beacons, inertial navigation, Doppler-radar systems, time-of-flight systems (Loran A and C; OMEGA), ILS and MLS, the general introduction of RNAV, advanced cockpit displays, digital buses, the GPS satellite navigation system, advanced inertial systems, and collision-avoidance systems. Drawings, diagrams, and photographs are provided.

T.K.

**A85-40310#**

#### **COMPAS - COMPUTER SUPPORT FOR APPROACH CONTROL [COMPAS - RECHNERUNTERSTUETZUNG FUER DIE ANFLUGKONTROLLE]**

U. VOELCKERS (DFVLR, Institut fuer Flugfuehrung, Brunswick, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 14 p. In German. refs

(DGLR PAPER 84-091)

Air Traffic Control (ATC) operations related to the approach of aircraft to large airports represent a demanding task for the controller. This task becomes increasingly more difficult with the introduction of a number of new factors. A project was, therefore, initiated in West Germany with the aim to obtain solutions and data for the design and the operation of a computer-aided system for ATC applications. The project includes the development and the testing of the Computer Oriented Metering Planning and Advisory System (COMPAS). COMPAS has the operational objective to utilize the available, limited landing runway capacity of commercial airports with a great traffic volume as effectively as possible, taking into account an avoidance or reduction of time delays with respect to approach operations. COMPAS is to provide planning operations regarding approach sequences and times, and in addition, it is to provide the controller with the data which he needs as a basis for making the decisions required for an early, efficient control of the approach traffic.

G.R.

**A85-40311#**

#### **AN EXPERIMENTAL PROGRAM FOR THE TESTING AND DEMONSTRATION OF GPS/NAVSTAR, TAKING INTO ACCOUNT APPLICATIONS IN CIVIL AVIATION [EIN VERSUCHSPROGRAMM ZUR ERPROBUNG UND DEMONSTRATION VON GPS/NAVSTAR FUER ANWENDUNGEN IN DER ZIVILLUFTFAHRT]**

K. D. KRICKE and V. HELD (ESG Elektronik-System-Gesellschaft mbH, Munich, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 15 p. In German. refs

(DGLR PAPER 84-092)

The introduction of GPS/Navstar will make available to users on land, on the water, and in the air a satellite-navigational system for obtaining, on a continuous basis, positional data of high accuracy. The present paper is concerned with a testing and demonstration program planned by the Federal Ministry for Research and Technology in West Germany. This program has the objective to test GPS-receivers which have been developed by the German industry. Essential GPS functions and characteristics are considered, and a description is provided of the planned GPS test and demonstration program. The program is to be conducted in 1985 and 1986. Tests regarding the utilization of GPS for civil aviation are discussed, taking into account tests concerning the technical system for long distance flights and aircraft approaches, and operational employment tests. Application areas of navigational systems for civil aviation are also examined, giving attention to long-term and short/intermediate-term usage.

G.R.

**A85-40918**

#### **AMES DEVELOPS REMOTE SITE LANDING AIDS**

J. T. MERRIFIELD Aviation Week and Space Technology (ISSN 0005-2175), vol. 122, June 10, 1985, p. 119, 121, 125.

NASA's Ames Research Center facility has undertaken the development of portable landing systems which will permit all-weather operation by aircraft at remote locations and the restoration of precision instrument approach capabilities for battle-damaged airfields. These landing aid concepts are designated the 'beacon landing system' (BLS) and 'portable tactical approach guidance' (PTAG) system. The BLS and PTAG, which are sequentially pulsed microwave duplicates of the conventional Instrument Landing System (ILS), are flown by reference to the existing cockpit ILS display and therefore require no change in piloting technique. BLS is intended for helicopter operations, while PTAG is to be employed by fixed wing aircraft.

O.C.

A85-40986#

**A METHOD OF ESTIMATING THE PROBABILITY OF VERTICAL OVERLAP USING OBSERVED HEIGHT DATA**

S. NAGAOKA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 364, 1984, p. 301-308. In Japanese, with abstract in English. refs

In general, probabilities of overlap which are key parameters in a collision risk model can be estimated from the frequency distribution of navigational errors. However, it is very difficult to determine the distribution of vertical navigational errors because the assigned altitude of aircraft is given by an isobaric surface (flight level) whose height depends on the atmospheric conditions. This paper describes a method of estimating the probability of vertical overlap of an aircraft pair without knowing the distribution function of vertical navigational errors directly. Using a pair of observed heights of aircraft (this is defined as the relative vertical distance), the probability of vertical overlap can be estimated from its frequency distribution empirically. Several cases of samplings and some results of a computer simulation carried out for an assumed error distribution in order to verify this method are discussed herein. Author

A85-41010#

**STATUS AND TRENDS OF MICROWAVE LANDING SYSTEM**

T. KATANO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 368, 1984, p. 503-510. In Japanese. refs

Recent developments in the microwave landing system (MLS) are surveyed. The MLS consists of ground and onboard facilities, with the ground facility including approach azimuth, approach elevation, basic data and DME/N or DME/P systems, and optional apparatus for back azimuth, flare elevation, and auxiliary data treatment. Advantages of the MLS include improvement of operation, reduction of noise, and landing guidance to the V/STOLs. All-weather MLS navigation may be possible in the future. S.H.

A85-41016#

**RADIO NAVIGATION SENSOR**

Y. HIRASHIMA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 369, 1984, p. 561-567. In Japanese. refs

Typical radio navigation sensor systems are discussed. Ground facilities reduce errors by the use of multipath techniques while onboard facilities employ tracking filters. The systems covered include Doppler navigation, Loran C, and Omega for range navigation, non-directional beacon/automatic direction finder, range measurement equipment, tactical air navigation, and VHF omnidirectional radio range (VOR) for short range navigation. The radio navigation sensor system for landing includes the instrument landing system (ILS) and microwave landing system (MLS) with time reference scanning beams. The MLS tests for determining error in angle measurement, control motion noise, and path following error are defined. S.H.

A85-41057#

**'FANCY RADIO' DEVELOPS SPLIT PERSONALITY**

E. J. LERNER Aerospace America (ISSN 0740-722X), vol. 23, July 1985, p. 66-69.

The Joint Tactical Information Distribution System (JTIDS) development program was initiated by the U.S. Department of Defense in 1974 as a tactical communications system that was to integrate all information available to fighting units of all three services during engagements. Although originally estimated to cost \$5000-10,000/portable unit, unit costs presently stand at about \$500,000. JTIDS as a whole has come to be characterized by substantial divergences, among three distinct service versions, from the original system's conception. Most notably, the Navy has chosen to supplant the TDMA technology incorporated by the other two services' systems with Distributed TDMA, which precludes communication with Army and Navy units. O.C.

A85-41321

**ADAPTIVE NOISE CANCELLATION IN A FIGHTER COCKPIT ENVIRONMENT**

W. A. HARRISON, J. S. LIM, and E. SINGER (MIT, Lexington, MA) IEEE, International Conference on Acoustics, Speech, and Signal Processing, San Diego, CA, Mar. 19-21, 1984, Paper. 4 p. refs

(Contract N00014-81-K-0742; NR PROJECT 049-506; NSF ECS-80-07102) (AD-A153178)

In this paper some preliminary results on using Widrow's Adaptive Noise Cancelling (ANC) algorithm to reduce the background noise present in a fighter pilot's speech are discussed. With a dominant noise source present and with the pilot wearing an oxygen facemask, it is demonstrated that good (greater than 10 dB) cancellation of the additive noise and little speech distortion can be achieved by having the reference microphone attached to the outside of the facemask and by updating the filter coefficients only during silence intervals. Author

A85-41399

**CMA-771 - A NEW OMEGA ONBOARD SYSTEM [CMA-771 - EINE NEUE OMEGA-BORDANLAGE]**

G. WESTPHAL (Interflug Gesellschaft fuer Internationalen Flugverkehr mbH, Berlin, East Germany) Technisch-oekonomische Information der zivilen Luftfahrt (ISSN 0232-5012), vol. 21, no. 2, 1985, p. 59-67. In German. refs

The developmental history, operating principles, and performance of the OMEGA navigation system are reviewed, and the CMA-771 computer-automated onboard system is characterized in detail. Consideration is given to the realization of the ground segment, VLF navigation, the CMA-771 design specifications, and the individual components of the equipment. Diagrams, graphs, and photographs are provided. T.K.

A85-41728

**THE ROLE OF AIR TRAFFIC CONTROL IN THE CO-ORDINATION OF CIVIL AND MILITARY OPERATIONS**

C. J. STOCK (Guild of Air Traffic Control Officers, Aylesbury, England) International Journal of Aviation Safety (ISSN 0264-6803), vol. 3, June 1985, p. 111-113.

The safety and national security criteria that must be met by joint military/civilian air traffic control operations are discussed, with major emphasis on Western Europe and specific reference to Britain. Where military missions in a given airspace are incompatible with, or even dangerous to, civilian operations; the reservation of that airspace becomes necessary and its restoration to civilian use must be carefully, but promptly, controlled. Recent increases in regional and domestic services to destinations lying outside recognized route structures significantly worsen the problem of civilian/military coordination. O.C.

A85-42247

**AIR NAVIGATION SYSTEMS [СИСТЕМЫ САМОЛЕТОВОЗДНЕНИЯ]**

A. N. KOPTEV Moscow, Izdatel'stvo Mashinostroenie, 1984, 128 p. In Russian. refs

The basic principles of air navigation systems are reviewed, and the automatic navigation systems of current aircraft are described. The navigation system is then examined from the standpoint of the theory of control systems as a complex consisting of transducers, and systems of manual, semiautomatic, and automatic control with actuating elements. In particular, attention is given to course-indicating systems, radio transducers, Doppler and inertial distance measuring systems, classification of aircraft control systems, electrohydraulic control systems, and automatic control systems. V.L.



## 04 AIRCRAFT COMMUNICATIONS AND NAVIGATION

**A85-42399#**

### **OBSERVABILITY OF RELATIVE NAVIGATION USING RANGE-ONLY MEASUREMENTS**

A. M. SCHNEIDER (California, University, La Jolla) IEEE Transactions on Aerospace and Electronic Systems (ISSN 0018-9251), vol. AES-21, July 1985, p. 569-581. refs

A simulation tool is described which is capable of determining the observability of various fleet configurations and maneuvers in a relative navigation environment. The motion of the relative grid established by the navigation controller is explicitly modeled as a function of the errors in his dead-reckoning sensors. The simulation uses centralized, optimal processing of an extended Kalman filter. Results show observability on a good geometry, with some degradation in performance when dead-reckoning sensor errors change rapidly. Author

**A85-43236#**

### **A PLANE-TRACKING METHOD**

P. JIA (Chinese Academy of Sciences, Institute of Systems Science, Beijing, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 5, Dec. 1984, p. 444-450. In Chinese, with abstract in English.

A method of real-time aircraft tracking is proposed which takes acceleration and turning into account. The method is based on a first order adaptive polynomial filter which can be used to calculate maneuvering based on the sum of the predicted aircraft residues, and variations in the level of noise emanating from the aircraft. The algorithms used to calculate the variation in aircraft noise are given. On the basis of several numerical simulations, both techniques are found to be satisfactory for tracking most types of aircraft. I.H.

**A85-43245#**

### **DESIGN OF AIRBORNE FIBER-OPTIC DATA BUS SYSTEM**

R. FAN, G. WANG, and R. CHEN (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Feb. 1985, p. 57-64. In Chinese, with abstract in English. refs

The development, communication standards, system structures, operating principles of airborne multiplex data bus and its sphere of application are discussed in this paper. A method using a microcomputer to design the intelligent terminal and bus controller of the system is described with emphasis on hardware and software design. The major problems concerning high speed, real-time, and secure transmission of data between computer and its interface are reviewed. The intelligent terminal and bus controller have been developed by means of 8086 computer. An experimental prototype has been made and its job programs debugged. The optical fiber data bus system consists of optical receivers, optical transmitters, an optical couple with eight ports, the bus controller, and the intelligent terminal. Some of the checkout tests have been completed at code rate of 1 Mbit/s with this system. The optic fiber transmission system are also considered and some experimental results are given. Author

**N85-29940#** Systems Control Technology, Inc., West Palm Beach, Fla.

### **MICROWAVE LANDING SYSTEMS FOR HELIPORT OPERATORS, OWNERS AND USERS Final Report**

K. J. VENEZIA and E. D. MCCONKEY Jun. 1985 52 p refs (Contract DTFA01-80-C-10080)

(FAA-PM-85-7) Avail: NTIS HC A04/MF A01

Information on the utilization of the Microwave Landing System (MLS) at heliports and helipads was compiled to familiarize heliport operators and users with the features of the MLS and its capabilities in supporting heliport operations. Information on MLS siting, operational characteristics, selecting and specifying an MLS system is presented. In addition, information to familiarize pilots with MLS avionics, pilot training requirements and aircraft performance considerations is also given. J.W.G.

**N85-29941#** Boeing Commercial Airplane Co., Seattle, Wash. Flight Systems Technology.

### **TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM: OPERATIONAL SIMULATION Final Report, Apr. 1982 - Mar. 1984**

G. P. BOUCEK, T. A. PFAFF, R. W. WHITE, and W. D. SMITH Washington FAA Mar. 1985 204 p refs Sponsored by FAA

(FAA-PM-85-10) Avail: NTIS HC A10/MF A01

One of a series of studies being conducted to develop the Traffic Alert and Collision Avoidance System (TCAS) is discussed. The purpose was to conduct a pilot evaluation of the relationship between TCAS displays, an operational crew station, aircraft performance, TCAS logic and operational TCAS procedures. The specific objectives of the evaluation were to be: (1) develop and evaluate the operational procedures associated with TCAS alerts under both normal and abnormal flight operations; (2) assess changes in flight deck operations associated with TCAS; (3) assess operational procedures as related to ATC control; and (4) assess the impact of TCAS display requirements on flight deck systems and geometry. During the evaluation experienced transport pilots were presented TCAS alerts while flying a high fidelity B737-200 training simulator. Their response to the alerts was observed and recorded as were their opinions concerning the system. As a result of reviewing pilot responses to 552 TCAS encounters with a total of 970 intruder aircraft, it is recommended that TCAS be revised to achieve more consistently correct pilot response. Author

**N85-29942#** Federal Aviation Administration, Washington, D.C. Management Standards and Statistics Div.

### **FAA AIR TRAFFIC ACTIVITY, FISCAL YEAR 1984 Statistical Report, 1 Oct. 1983 - 30 Sep. 1984**

N. TREMBLEY 30 Sep. 1984 220 p

(AD-A154318) Avail: NTIS HC A10/MF A01 CSCI 01E

Terminal and en route air traffic activity information (statistical data) of the National Airspace System, FY 1984 is given. The data were reported by the FAA-operated Airport Traffic Control Towers (ATCTs), Air Route Traffic Control Centers (ARTCCs), Flight Service Stations (FSSs), International Flight Service Stations (IFSSs), and Approach Control Facilities. R.J.F.

**N85-31035\*#** Ohio Univ., Athens.

### **A STUDY OF THE APPLICATION OF DIFFERENTIAL TECHNIQUES TO THE GLOBAL POSITIONING SYSTEM FOR A HELICOPTER PRECISION APPROACH**

D. L. MCCALL Nov. 1984 83 p refs

(Contract NAG2-231)

(NASA-CR-177326; NAS 1.26:177326) Avail: NTIS HC A05/MF A01 CSCI 17G

The results of a simulation study to define the functional characteristics of a airborne and ground reference GPS receiver for use in a Differential GPS system are documented. The operations of a variety of receiver types (sequential-single channel, continuous multi-channel, etc.) are evaluated for a typical civil helicopter mission scenario. The math model of each receiver type incorporated representative system errors including intentional degradation. The results include the discussion of the receiver relative performance, the spatial correlative properties of individual range error sources, and the navigation algorithm used to smooth the position data. Author

**N85-31036#** Committee on Commerce, Science, and Transportation (U. S. Senate).

### **STATUS OF AIR TRAFFIC CONTROL SYSTEM**

Washington GPO 1985 102 p Hearing before a Subcomm. on Aviation of the Comm. on Com., Sci, and Transportation (S-HRG-98-1197; GPO-40-733) Avail: Subcommittee on Aviation

A hearing was conducted by the Senate subcommittee on aviation to determine the status of civilian air traffic control. Both equipment and personnel were assessed. G.L.C.

**N85-31037#** Ohio Univ., Athens. Dept. of Electrical and Computer Engineering.

**THEORETICAL INVESTIGATION OF SINGLE-FREQUENCY 8-ELEMENT LOCALIZER SIGNAL SCATTERING FOR CRITICAL AREA DETERMINATION Final Report**

W. D. PHIPPS May 1985 192 p refs  
(FAA/PM-85-4) Avail: NTIS HC A09/MF A01

A theoretical investigation of the log-periodic, 8-element, single-frequency localizer has been performed to establish critical area criteria for all categories of instrument landing system (ILS) operation. Contour maps are provided which predict the peak localizer CDI perturbation in each ILS zone for various sizes, locations, and orientations of scatterer aircraft in the vicinity of the localizer transmitting array. Also, plots are provided indicating locations at which the presence of an interfering aircraft will cause the radiated signal of the 8-element localizer to exceed Category 1, Category 2, or Category 3 tolerances, specified in U.S. Flight Inspection Manual 82100.1. Additionally, comparative data for the log-periodic, 14-element, single-frequency localizer are presented.

Author

**N85-31038#** Societe Nationale Industrielle Aerospatiale, Toulouse (France). Div. Avion.

**AVIONICS AND CIVIL AIRCRAFT SYSTEMS: THE PRESENT AND THE FUTURE [AERO-ELECTRONICA Y SISTEMAS DE LOS AVIONES CIVILES: EL PRESENTE Y EL FUTURO]**

J. P. LABORIE 18 Feb. 1985 44 p In FRENCH and SPANISH Presented at GIFAS Semaine Aerospatiale Francaise de Conf. Tech., Madrid, 12-15 Jun. 1984  
(SNIAS-851-111-104) Avail: NTIS HC A03/MF A01

The technological progress in the design of avionics systems from the Concorde to the Airbus family is described. The weight reduction, cost advantages and ease of maintenance obtained with numerical techniques and laser gyros are discussed. The ergonomic advantages introduced with the extensive use of cathode ray displays are pointed out. The design trends for the A310 and longer term evolution are examined. Author (ESA)

**N85-31039#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Abt. Anthropotechnik und Simulation.

**A FEASIBILITY STUDY FOR THE USE OF ELECTRONIC FLIGHT STRIPS IN ATC CONTROLLER WORKSTATIONS**

J. GRIGAT and J. THOMAS Nov. 1984 90 p refs In GERMAN; ENGLISH summary Report will also be announced as translation (ESA-TT-928) Original contains color illustrations (DFVLR-FB-85-08; ISSN-0171-1342) Avail: NTIS HC A05/MF A01; DFVLR, Cologne DM 47

Flight progress strip importance in air traffic control was studied and a concept for flight strip representation on electronic four-color displays supported by an automatic data exchange between adjacent control stations and adapted to the ATMOS air traffic control simulation was developed. Data important for executive controllers and for schedule controllers per sector and per flight are displayed on two different screens. The concept allows a rapid exact data exchange to all workstations and a reduction in the controllers data acquisition so that they can dedicate their attention to approach monitoring. Pilot communications are also reduced. The feasibility of the concept is demonstrated in a case study. Author (ESA)

**N85-31040#** Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt, Brunswick (West Germany). Abt. Kreiselgeraete und Traegheitsnavigation.

**SIMULATIONS OF STRAPDOWN-SYSTEM ERRORS AND ERROR COMPENSATION METHODS**

V. WETZIG and H. ZHUGE (Chinese Aeronautical Establishment, Xian) Nov. 1984 179 p refs Sponsored by DFVLR and Chinese Aeronautical Establishment  
(DFVLR-MITT-84-22; ISSN-0176-7739) Avail: NTIS HC A09/MF A01; DFVLR, Cologne DM 57

A strapdown inertial navigation system computer model analyzed system error with regard to error source, flight

environment, and sensor error compensation method. Constant and periodic rotation of the instrument unit to reduce system error was investigated. Flight paths were generated as a low frequency random sequence of curve sections. High frequency vibrations were superimposed. Linearized sensor error models were used. After circular flight, paths system error effects of all sensor error groups are smaller than for nearly straight flight paths. Open loop sensor compensation results are incomplete because the same algorithms were used for creating and compensating the sensor errors. The sinusoidal rotation of the inertial measurement unit is nearly as effective as constant rotation, and gives 80% error reduction. Author (ESA)

**N85-31041#** European Space Agency, Paris (France).

**USING REGRESSION ANALYSIS FOR DETERMINING AIR DATA SENSOR ERRORS BY MEANS OF AN INERTIAL NAVIGATION SYSTEM**

H. J. HOTOP Dec. 1984 70 p refs Transl. into ENGLISH of "Anwend. der Regressionsanal. zur Ermitt. der Luftdaten-Sensorfehler mittels eines Traegheitsnavigationssystems", Brunswick, Rept. DFVLR-Mitt-84-03, 1984 Original language doc. previously announced as N84-27716

(ESA-TT-886; DFVLR-MITT-84-03) Avail: NTIS HC A04/MF A01; original German version available from DFVLR, Cologne DM 25

Error models for the calculation of air data sensor errors and of the wind using a pitot static system or a flight log for the true airspeed are described. Ground speed was based on an inertial navigation system. The different models were evaluated by regression analysis methods. Flight tests produce an estimated airspeed error of 3%. A comparison with external data from a weather bureau results in a mean difference of + or - 2 m/sec and the 2 chosen flight tests produce an air speed error of 5%. Author (ESA)

**N85-31043#** European Space Agency, Paris (France).

**EVALUATION OF RADIO NAVIGATION SYSTEMS AND THEIR CONFIGURATION WITH RESPECT TO MINIMUM COST**

W. GERLING Jul. 1984 45 p refs Transl. into ENGLISH of "Kostenoptimale Konfigurierung von Funknavigationsanlagen u. Bewertung konkurrierender Systeme" rept. DFVLR-FB-83-32 DFVLR, Brunswick 1983 Original language report previously announced as N84-19329

(ESA-TT-847; DFVLR-FB-83-32) Avail: NTIS HC A03/MF A01; original German version available from DFVLR, Cologne DM 15.50

Different Rho/Theta and Rho/Rho navigation systems were compared to find minimum cost configurations of ground equipment, using methods that yield the minimum number of ground stations and their most favorable locations. The VHF Omrange navigation/Distance measuring equipment (VOR/DME) systems are found to be applicable, but increased navigational efficiency standards are limited by the degree of accuracy of DME. The DME-supported azimuth systems (DAS) fulfil the same requirements at a substantially lower cost; DAS heavy-duty systems have only small advantages compared to basic DAS systems. The DME/DME systems represent an interesting alternative to DAS at similar cost, but limited accuracy limits the approachable navigational efficiency as for VOR/DME. Author (ESA)

## 05 AIRCRAFT DESIGN, TESTING AND PERFORMANCE

05

### AIRCRAFT DESIGN, TESTING AND PERFORMANCE

Includes aircraft simulation technology.

**A85-40069**

#### **ADVANCED TACTICAL FIGHTER - HOLDING FOR LAUNCH**

B. SWEETMAN Interavia (ISSN 0020-5168), vol. 40, June 1985, p. 605-607.

An evaluation is made of the development status of the airframe materials and structural techniques, powerplant cycle characteristics, advanced avionics, and configurational possibilities that are under discussion for integration in the U.S. Air Force's new-generation Advanced Tactical Fighter (ATF). The ATF must be able to cruise at Mach 1.5-2.0 with full weapons load, but without resort to afterburners; this capacity for low fuel consumption supersonic flight is held to be the basis for high altitude overflight of enemy territory with minimum exposure to the threat posed by surface-to-air missiles. Attention is given to the advanced cockpit systems being contemplated for pilot workload reduction and mission effectiveness enhancement. O.C.

**A85-40071**

#### **AIRLINES REACH OUT FOR LONGER RANGE - TWINS CROSS THE ATLANTIC; LONG-HAUL FLIGHTS GET LONGER**

D. WOOLLEY Interavia (ISSN 0020-5168), vol. 40, June 1985, p. 625-628.

An evaluation is made of the current state of long range passenger and cargo services by major airlines, with attention to the transport aircraft technology refinements and, especially, high bypass turbofan engine specific fuel consumption reductions, which facilitate longer and safer flights. The aircraft primarily employed in long range routes are the 747-300B, 767-200ER, A300, and A310. The recent FAA Advisory circular on extended range twin engined aircraft operations, which ends the monopoly of North Atlantic routes by four-engined aircraft for safety reasons, is discussed, together with existing plans by U.S. and by European consortium manufacturers for the development of more efficient long range transports. O.C.

**A85-40072**

#### **GP.180 - REACHING FOR AN IDEAL**

M. GRANGIER Interavia (ISSN 0020-5168), vol. 40, June 1985, p. 675-678.

Attention is given to the innovative system and configuration features of the twin turboprop GP.180 executive aircraft. The cruise speed of this aircraft, at 740 km/h, is approximately 100 km/h faster than its competitors and makes for a New York to Dallas flight time of only 3 hours and 30 minutes. The basis of this performance lies substantially in the use of a nonconstant-section fuselage and area-ruled nacelles for two wing-mounted engines; the propeller wakes in this configuration cannot affect wing boundary layer flow. Although the primary structure is metallic, extensive use of composites is noted in secondary structures. The standard version of the GP.180 will carry crew of two and seven passengers. O.C.

**A85-40283#**

#### **PROTECTION OF CARBON-FIBER REINFORCED ARTIFICIAL MATERIALS AGAINST DAMAGE BY LIGHTNING [BLITZSCHUTZ VON KOHLEFASERVERSTAERKTEN KUNSTSTOFFEN]**

K. WOITHE (Industrieanlagen-Betriebsgesellschaft mbH, Ottobrunn, West Germany) DGLR, Symposium ueber Entwicklung und Anwendung von CFK-Strukturen, Technische Universitaet Berlin, West Germany, Nov. 8, 9, 1984. 15 p. In German. refs (DGLR PAPER 84-151)

The types of damage caused by lightning strikes on fiber solid solution materials used in aircraft are described and suitable

measures to prevent the damage are discussed. The results of experimental research on such protective measures are summarized, emphasizing damage to and methods to protect carbon fiber composite plates, sandwich plates, and disassembly points. Practical examples of protective systems in a Tornado, Alpha Jet, and Airbus 310 are given. C.D.

**A85-40286**

#### **STABILITY LIMITS OF SHEAR FIELDS OF THE CARBON-FIBER-REINFORCED-PLASTICS RUDDER UNIT - AIRBUS A300/A310 [STABILITAETSGRENZEN VON SCHUBFELDERN DES CFK-SEITENLEITWERKS AIRBUS A300/A310]**

R. HILGERT (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, West Germany) DGLR, Symposium ueber Entwicklung und Anwendung von CFK-Strukturen, Technische Universitaet Berlin, West Germany, Nov. 8, 9, 1984. 46 p. In German. (DGLR PAPER 84-155; MBB-UT-42-84)

Since 1978, a carbon-fiber-reinforced-plastic rudder assembly is being developed by a west German aerospace company. The rudder assembly is intended for the Airbus types A300/A310. One of the objectives of this development is related to the lowering of the structural weight of the supporting medium box section by approximately 22 percent. An important requirement regarding the design of the new unit is the preservation of the external geometry used in the case of the aluminum rudder assembly. Meeting this requirement will make it possible to exchange an aluminum rudder assembly for a carbon composite rudder assembly. In connection with the component dimensions and the external loads, the rudder unit is designed on the basis of stiffness considerations. The calculation of the stability limits of rudder unit components is, therefore, an important factor in the demonstration of the static strength characteristics. Shearing tests were performed to demonstrate that the spar webs meet the static strength requirements. G.R.

**A85-40287#**

#### **THE STATIC AEROELASTICITY OF THE ANISOTROPIC WING [DIE STATISCHE AEROELASTIZITAET DES ANISOTROPEN TRAGFLUEGELS]**

M. PIENING (DFVLR, Institut fuer Strukturmechanik, Brunswick, West Germany) DGLR, Symposium ueber Entwicklung und Anwendung von CFK-Strukturen, Technische Universitaet Berlin, West Germany, Nov. 8, 9, 1984. 33 p. In German. refs (DGLR PAPER 84-158)

Components made of fiber-reinforced plastics are increasingly used in the construction of aircraft. In certain preferred directions, these materials have characteristics which are superior to those of the employed metallic materials. However, in other directions, the corresponding values can be much lower. For this reason, it appears advisable to utilize the high strength and stiffness of the fibers by orienting them in the direction of the stress. Such an approach makes it possible to employ lighter components and increase performance. Weisshaar (1978, 1979) has studied the aeroelastic stability and performance characteristics of aircraft with advanced composite sweptforward wing structures. The extends the solutions, provided by Diederich and Budiansky (1948) for isotropic wings, to anisotropic cases. The present investigation is concerned with the use of a structural model with characteristics which are refined compared to the previous models. A computation of arbitrary geometries and stress conditions is, therefore, possible. G.R.

A85-40303#

**DESIGN CONSIDERATIONS FOR TRANSPORT AIRCRAFT WITH MODERN PROPELLER PROPULSION  
[ENTWURFSUEBERLEGUNGEN ZU TRANSPORTFLUGZEUGEN MIT MODERNEN PROPELLERTRIEBWERKEN]**

H.-G. SCHULZ (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 41 p. In German.

(DGLR PAPER 84-083; MBB-UT-04-84)

The history of advanced propeller design since about 1970 is traced, and the results of propeller-transport-aircraft (PTA) configuration studies conducted cooperatively by Lufthansa, MTU, and MBB are summarized and illustrated with drawings and graphs. Turbine engines with simple and counterrotating pusher and tractor propellers are considered, and PTA configurations representing modifications of the turbofan-propulsion A 320 aircraft are compared for a 150-passenger 2300-n.m. Mach 0.76 mission at cruising altitude 35,000 ft. PTA with wing-mounted, tail-unit-mounted, and aft-mounted engines are shown to involve different aerodynamic problems (due to wing and center-of-gravity shifts) and disadvantages (especially limited servicing access to the PTA fuselage and increased noise levels requiring extra sound insulation) but to offer potential fuel savings of 15 percent or more. T.K.

A85-40304#

**NEW POSSIBILITIES FOR FUTURE AMPHIBIAN AIRCRAFT  
[NEUE MOEGlichkeiten FUEr ZUKUEFTIGE AMPHIBISCHE FLUGZEUGE]**

H. LIESE (Dornier GmbH, Friedrichshafen, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 16 p. In German.

(DGLR PAPER 84-084)

The development of new amphibian aircraft (AAs) is discussed, with an emphasis on efforts underway at Dornier. The missions for which AAs are best suited are examined, including monitoring of fishing and navigation, control of smuggling and illegal immigration, detection of oil spills, search and rescue, and firefighting. The combined performance requirements for these missions are summarized in tables: payload 5400 kg, range 2800 km, airspeed 200 kts, altitude 10,000 ft, and STOL capability in relatively rough seas. It is shown that the current three-engine Dornier experimental AA, despite good overall performance, requires a number of significant modifications to approach this level of performance. The world market for AAs through the year 2000 is estimated at 353 aircraft. T.K.

A85-40309#

**THE REDUCTION OF FUEL CONSUMPTION ON THE BASIS OF PERIODIC OPTIMAL FLIGHT PATHS [VERRINGERUNG DES TREIBSTOFFVER-BRAUCHS DURCH PERIODISCHE OPTIMAL-FLUGBAHNEN]**

G. SACHS (Muenchen, Technische Universitaet, Munich, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 18 p. In German. refs

(DGLR PAPER 84-090)

Questions regarding the minimization of fuel consumption for an aircraft in the case of a given flight distance or flight time have already been studied under the assumption that motion and control parameters can be classified as stationary or quasi-stationary. Afterwards it has been found that the conditions of a steady-state cruise are nonoptimal with respect to fuel consumption. A further reduction in fuel consumption is, therefore, often possible by conducting a flight under conditions of the 'periodic optimal control' of an atmospheric vehicle. Under the considered conditions, state and control quantities have periodic characteristics, and the entire flight will consist of a number of uniform, repetitive cycles. The present investigation is concerned with periodic optimal trajectories, taking into account the aim of a reduction in fuel consumption. Attention is given to the basic characteristics of periodic optimal trajectories, the improvement

provided by periodic optimal trajectories in comparison to a flight conducted under stationary conditions, and the significance of various parameters. G.R.

A85-40312#

**THE DFVLR FLIGHT-TEST VEHICLE ATTAS  
[FLUGVERSUCHSTRAEGER ATTAS FUEr DIE DFVLR]**

H. GRIEM (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 33 p. In German.

(DGLR PAPER 84-093; MBB-UT-17-84)

The DFVLR Advanced Technologies Testing Aircraft System (ATTAS), currently undergoing ground and flight tests to permit operation beginning in 1986, is characterized in detail and illustrated with photographs, drawings, diagrams, graphs of component performance, and tables of numerical specifications. The testing aims of ATTAS include integrated digital flight-control systems, flight-safety systems, wing aerodynamics, and inflight simulation of active control systems. Consideration is given to the actuation parameters, the control-system configuration and safety concept, cockpit controls and displays, data-processing systems, experimental cabin configurations, electrical and hydraulic energy systems, and the test programs planned to qualify ATTAS. T.K.

A85-40317#

**COCKPIT LAYOUT BY COOPERATION BETWEEN AIRCRAFT MANUFACTURER AND AIRLINE COMPANIES [COCKPIT LAYOUT IM ZUSAMMENWIRKEN VON FLUGZEUGHERSTELLER UND LUFTVERKEHRSGESELLSCHAFTEN]**

J.-P. HACH (Deutsche Lufthansa AG, Hamburg, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 9 p. In German.

(DGLR PAPER 84-098)

The role of airlines in influencing the design of aircraft cockpits to meet specific operational requirements is illustrated with three examples from the experience of Lufthansa. The aircraft discussed are the B 737-230 adv. (airline-requested modification of an existing design), the A 310 (the extensive influence of a launching customer), and the A 320 (the advisory role of a potential customer). T.K.

A85-40327#

**THE MODERN FIGHTER AIRCRAFT - COMPARATIVE CONFIGURATIONAL CONSIDERATIONS [DAS MODERNE KANDFLUGZEUG - VERGLEICHENDE KONFIGURATIONSBETRACHTUNGEN]**

E. OBERDOERFFER and G. WEDEKIND (Dornier GmbH, Friedrichshafen, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 26 p. In German.

(DGLR PAPER 84-110)

Configurational trends in the development of the aircraft since the flight of the Wright brothers are briefly examined, taking into account the entirely new possibilities for the design of a fighter provided by digital control systems. The requirements which a modern fighter aircraft will have to satisfy are analyzed on the basis of a study of the situations which can arise in combat with enemy aircraft. The necessity to conduct flight operations under subsonic and supersonic conditions leads to contradictory demands with respect to the wing design. The arising difficulties can be overcome with the aid of 'maneuver flaps' and the utilization of suitably programmed digital flight control systems. Attention is also given to the occurrence of instability conditions, stabilization with the aid of a flight controller, the limits of instability, the improvement of flight conditions by means of elevator units, relations at supersonic speed, design examples involving three different configurations, and the sensitivity of flight performance to a displacement in the center of gravity. G.R.

A85-40329

**THE EMPLOYMENT OF 3-D PROGRAMS IN AIRCRAFT DESIGN  
[EINSATZ VON 3-D PROGRAMMEN IM FLUGZEUGENTWURF]**

H. ROSS (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 33 p. In German.

(DGLR PAPER 84-113; MBB-LKE-11/S/PUB/146)

Since the mid-1960s, aircraft firms have used computer-aided design (CAD) programs for the creation and/or variation of parametric drafts. The development of the required CAD programs requires a logical connection of essential subprograms describing the design. The values of the technical parameters are varied on the basis of a fundamental configuration. This configuration is in most cases established outside the program. The present investigation is concerned with programs which can be employed as a 'mathematical tool' for the design process. The programs are used for the mathematical definition of surfaces and bodies, taking into account also kinematic problems. The considered programs permit three-dimensional design and representation. For this reason, they are generally designated as 'three-dimensional programs' (3-D). A description of the design process is given to provide a basis for the derivation of the requirements which a 3-D program will have to satisfy. Attention is given to currently available programs, and the utilization of 3-D programs in a German aerospace company.

G.R.

A85-40339#

**ARGUS - STANDOFF-RECONNAISSANCE WITH UNMANNED ROTOR PLATFORM [ARGUS - STAND-OFF-AUFKLAERUNG MIT UNBEMANNTER ROTORPLATTFORM]**

H.-J. BANGEN (Dornier GmbH, Friedrichshafen, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 18 p. In German. refs (DGLR PAPER 84-126)

The German Army is concerned with the conduction of reconnaissance operations providing information regarding the presence of mobile and immobile target objects. The reconnaissance requirements can only be satisfied by an approach involving the cooperation of penetrating and standoff media. There are certain delays regarding the reception of information provided by aircraft or satellites. For this reason, the Army wants to ensure a meaningful employment of its new long-range weapons by making use of supplementary means of reconnaissance. Fast-flying drone vehicle systems are to be used to penetrate into the airspace of the involved area. In addition, use is to be made of slow penetrating drones and a mobile standoff reconnaissance system. The required information is to be obtained with the aid of a radar which is maintained at a suitable height by means of a VTOL RPV utilizing a lifting rotor. Details concerning the design and the operation of the considered system are discussed.

G.R.

A85-40459#

**STRUCTURAL ANALYSIS OF THE CL-600 REAR PRESSURE BULKHEAD, USING NASTRAN NONLINEAR ANALYSIS CAPABILITIES (SOLUTION 64)**

A. OBERTI (Canadair, Ltd., Montreal, Canada) (Canadian Aeronautics and Space Institute, Annual General Meeting, 31st, Ottawa, Canada, May 28, 29, 1984) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 30, Dec. 1984, p. 328-346.

The NASTRAN nonlinear analysis Solution 64 is presently applied to the structural analysis of the rear pressure bulkhead of the Challenger executive jet's CL-600 variant. The nonlinearity arises from the stretching of the bulkhead sheet, between vertical stiffeners, due to pressure loading. The analysis is limited to pressures no greater than 9.35 psi because of the severity of the nonlinear problem, which would otherwise have required a very fine mesh and a large number of nonlinear iterations. The NASTRAN results are compared with strain gage readings taken during pressurization tests with the CL-600 airframe. Attention is given to problems encountered in the definition of a representative finite element model that would be valid for nonlinear analysis.

O.C.

A85-40462#

**THE BRISTOL WIRE STRIKE PROTECTION SYSTEM**

M. H. COOPER (Bristol Aerospace, Ltd., Winnipeg, Canada) (Canadian Symposium on Aerospace Structures and Materials, 2nd, Ottawa, Canada, May 29, 1984) Canadian Aeronautics and Space Journal (ISSN 0008-2821), vol. 30, Dec. 1984, p. 363-370.

The Wire Strike Protection System (WSPS) is an entirely passive wire cutting device for low-flying helicopters which uses no moving parts and does not have to be given any consideration by the pilot. Attention is presently given to the results of a test program for the determination of loads generated by the impact of wires on helicopter airframes equipped with the WSPS. A total of 39 tests were conducted at vehicle speeds of 15-60 mph, at cut angles of 45-90 deg, using wires rated to 13,500 lb minimum tensile strength.

O.C.

A85-40553#

**SIMULATOR EVALUATION OF F/A-18 SKI JUMP**

B. L. DOUGHERTY and D. R. ROLSTON (McDonnell Aircraft Co., St. Louis, MO) IN: Flight Simulation Technologies Conference, St. Louis, MO, July 22-24, 1985, Technical Papers. New York, AIAA, 1985, p. 6-10. refs

(AIAA PAPER 85-1730)

The paper discusses the development and evaluation of the simulator effort involved in a recent Navy ski jump program. It was found that update rate and detail design of the landing gear and ramp models were critical factors in producing this highly effective man-in-the-loop simulation. Comparison of simulator and flight test data demonstrate the usefulness of this simulator in augmenting the flight test program.

Author

A85-40565#

**ROTOR DYNAMICS SIMULATION - A NEW APPROACH**

F. M. CARDULLO (New York, State University, Binghamton), W. J. HEWITT (Consultants in Simulation, Inc., Harpursville, NY), and K. KNIGHT (AAI Corp., Houston, TX) IN: Flight Simulation Technologies Conference, St. Louis, MO, July 22-24, 1985, Technical Papers. New York, AIAA, 1985, p. 97-99.

(AIAA PAPER 85-1739)

The existing 'blade element' and 'rotor map' methods for rotor dynamics simulations are presently combined in a manner that retains the strength of each while mitigating their relative weaknesses. This 'performance-driven blade element method' makes the blade airfoil coefficients of lift and drag four-dimensional functions of the three independent variables (1) crossflow ratio, (2) inflow ratio, and (3) blade pitch at the 0.75-radius blade station, together with the element angle-of-attack. These functional coefficients are stored in data maps suitable for linear interpolation between entries, making thousands of data entries available for adjustment to facilitate performance correlation. An optimization technique further enhancing this method is presented which systematically adjusts the functional coefficients to correspond with aircraft performance for each test point.

O.C.

A85-40811# Wichita State Univ., Kans.

**ELECTRO-IMPULSE DE-ICING OF A TURBOFAN ENGINE INLET**

G. W. ZUMWALT (Wichita State University, KS) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 8 p. refs

(Contract NAG3-284)

(AIAA PAPER 85-1118)

The application of electromagnetic impulse deicing (EIDI) systems to turbofan engine inlets on business aircraft has been investigated experimentally. The tests were performed in the Icing Research Tunnel at NASA's Lewis Research Center. The deicing system testbed was a Falcon Fanjet 20 engine nacelle. The effectiveness of various deicing coil configurations and mount designs were compared, and design parameters were developed specifically for EIDI systems in turbofan engines. Flight tests were also carried out at altitudes in the range 3000-6000 ft corresponding to a temperature range of -3 to -8 C. It is shown that the ice particles removed from the engine inlet by the deicing system

were small enough for the engine to ingest. Tentative design specifications are given with respect to the optimum coil configuration, and operating power of a EIDI production candidate. I.H.

#### A85-40907

##### LOCKHEED DEVOTING KEY RESOURCES TO ADVANCED TACTICAL FIGHTER

M. A. DORNHEIM Aviation Week and Space Technology (ISSN 0005-2175), vol. 123, July 22, 1985, p. 143, 145-147, 149, 151.

The current mobilization of a major military aircraft manufacturer's research and development resources for competition with other firms in the U.S. Air Force's Advanced Tactical Fighter (ATF) program is discussed. The ATF will probably incorporate radar cross section- and IR emissions-minimizing 'stealth' technologies, as well as standoff range missiles and engines with sufficiently low fuel consumption to permit extended supersonic cruise without the use of afterburners. Extensive use will be made of advanced aluminum alloys and thermoplastic matrix composites whose higher operational temperatures are more in keeping with the extended supersonic cruise requirement of the ATF. Emphasis is being put on the supportability and reliability of ATFs deployed in NATO bases. O.C.

#### A85-40911#

##### ATR 42 - THE DEFINITIVE CONFIGURATION CERTIFICATION PROGRAM BEGUN

A. PARTIOT Revue Aerospatiale (ISSN 0065-3780), April 1985, p. 12-14. Translation.

Significant features of the certification trials for the dual turboprop-powered ATR42 short range passenger aircraft are outlined. The normal operating envelope has been validated up to 250 kt. Airspeed will be pushed to 290 kt to define safety margins, which will also require the demonstration of stall conditions. The aircraft has proven capable of flight with a shorter runway than expected from the design. All primary controls are mechanically linked, and natural trim tabs are also included. The certification tests have covered cold weather conditions, performance of the autopilot and auxiliary controls, in-flight engine restart, and emergency procedures in partial equipment failure conditions. M.S.K.

#### A85-40920#

##### THE 'SPHERIFLEX' - A NEW ROTOR-HUB CONCEPT

R. MOUILLE Revue Aerospatiale (ISSN 0065-3780), June 1985, p. 58-61.

The Spheriflex helicopter rotor hub was developed to improve the simplicity, cost, weight, compactness, reliability, safety and maintenance characteristics associated with the previous Starflex hub. The new hub is made of composites, has no flexible arm attached to the blade, and has a reciprocal stop ring to support the blades. Frequency matching units between the hub and the cuffs joining the stop to the blades furnish the appropriate stiffness and lag-motion damping. It is expected that some of the 70 components will have an infinite service life. M.S.K.

#### A85-40954#

##### ICFD - INTERDISCIPLINARY COMPUTATIONAL FLUID DYNAMICS

W. L. HANKEY (Wright State University, Dayton, OH) IN: Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers. New York, AIAA, 1985, p. 313-321. refs (AIAA PAPER 85-1522)

Interdisciplinary Computational Fluid Dynamics is that field in which the Navier-Stokes equations are coupled to another set of equations for the solution of interaction problems. Although it is currently possible to apply numerical algorithms and grid generation methods to such problems, together with the conservation form for governing equations and arrangements of field data which exploit vector processor hardware, novel technology is called for in the modeling of complex interface boundary conditions and the incorporation of constitutive relationships for state variables and

transport processes. It is also necessary to model such subgrid scale phenomena as turbulence, evaporation, atomization, devolatilization, nucleation, chemical reactions, surface tension, and surface roughness. O.C.

A85-41054\*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

##### READYING TECHNOLOGY FOR A SUPER SST

R. H. PETERSEN and C. DRIVER (NASA, Langley Research Center, Hampton, VA) Aerospace America (ISSN 0740-722X), vol. 23, July 1985, p. 56-59.

A technology readiness evaluation is made of the configurational, propulsion system, avionics, and materials/manufacturing methods which could be integrated to produce an economically viable SST by the year 2000. Aerodynamically, promising results are noted in the cases of arrow-wing planforms and blended wing/body cross sections, as well as in vortex flaps. In structures, metal matrix composites with high specific strength at high temperatures and thermoplastically formed/diffusion-bonded titanium alloy sandwich structures are identified as being of primary importance. Performance improvement prospects are also noted for engine efficiencies and sonic boom overpressures. The various technologies are envisaged as the bases for a two-engine, two-crew cockpit, 250-seat arrow-winged SST. O.C.

#### A85-41056#

##### C-5B - A GIANT REBORN

H. B. ALLISON (Lockheed-Georgia Co., Marietta, GA) Aerospace America (ISSN 0740-722X), vol. 23, July 1985, p. 62-65.

The factors which have led to the development and procurement of the C-5B variant of the 'Galaxy' airlifter by the U.S. Air Force are discussed, with emphasis on the performance improvements and production efficiencies respectively gained through the refinement of systems and the great degree of commonality maintained with the C-5A. Attention is given to the incorporation of state-of-the-art aluminum, titanium and ferrous alloys in the new variant to yield increased structural durability, corrosion prevention, and stress corrosion resistance. State-of-the-art avionics, weather radar, and carbon brakes are used, together with upgraded TF-39 engines. O.C.

#### A85-41067

##### F-14D - TOMORROW'S TOUGHER TOMCAT

Horizons (ISSN 0095-7615), vol. 21, no. 2, 1985, p. 10-17.

An evaluation is made of the extent to which the performance and weapons carriage advantages anticipated for the F-14D Navy air superiority fighter address the threats posed by improvements in the Soviet naval arsenal, which is noted likely to include a greater number of Backfire bombers than the 100 once envisioned. The F-14D weapons suite will encompass the APG-71 digital radar system, the Joint Tactical Information Distribution System, an airborne self-protection jammer, and the Advanced Medium Range Air-to-Air Missile. Performance gains are substantially based on the use of the F101 Derivative Fighter Engine powerplant, which yields 30 percent higher thrust despite significantly lower specific fuel consumption. Avionics will have substantial commonality with those of the F/A-18 and AV-8B carrier-based aircraft. O.C.

#### A85-41068

##### THE V-22 OSPREY

T. THOMASON (Bell Helicopter Textron, Fort Worth, TX) and W. LIEBERMAN (Boeing Vertol Co., Philadelphia, PA) Horizons (ISSN 0095-7615), vol. 21, no. 2, 1985, p. 18-25.

The present development history of the V-22 'Osprey' Navy/Marine Corps/Army VTOL tilt-rotor aircraft, formerly designated 'JVX', notes the range of alternative VTOL high performance configurational concepts with which the tilt-rotor principle has competed and emphasizes the advantages derived from the painstaking validation of this radical technology in the XV-3 and XV-15 experimental aircraft programs. Attention is given to the wing/prop rotor stowage system that has been developed to facilitate V-22 accommodation aboard capital ships and aircraft

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carriers, and to the mission capability improvements over the XV-15 that result from greater size and payload. Extensive use is made of composites in the V-22's primary structures, in order both to reduce weight and improve battle damage tolerance. O.C.

**A85-41069**

### **ROTOR SYSTEM DESIGN - AN ADVENTURE IN COMPROMISE**

J. H. BRAHNEY Aerospace Engineering (ISSN 0736-2536), vol. 5, July 1985, p. 8-21.

The history of helicopter rotor-system design is traced, and advanced designs currently being developed are examined, in a general review. Consideration is given to rotor configurations (single-main-rotor, tandem, side-by-side, coaxial, and intermeshed), strategies to eliminate the tail rotor (including blade-tip jets, vertical stabilizers, and cylindrical air blowing), blade profiles and tapering, hub configurations (rigid, semirigid, fully articulated, and bearingless), rotor control and directional stability, and X-wing aircraft capable of operation in both helicopter and (high-speed) fixed-wing modes. Photographs, drawings, and diagrams are provided. T.K.

**A85-41070**

### **ENVIRONMENTAL CONTROL SYSTEMS FOR HELICOPTERS COMPARED**

Aerospace Engineering (ISSN 0736-2536), vol. 5, July 1985, p. 22-26.

The performance of bleed-air-powered, engine-driven-compressor-powered, and vapor-cycle environmental-control systems (ECSs) for commercial passenger helicopters is evaluated, summarizing the results of a comparative investigation (Buckingham, 1984). The operating principles and design configurations of the three types of ECS are reviewed and illustrated with diagrams, and the results of installed-shaft-horsepower, specific-fuel-consumption, and overall-lift-penalty analyses are presented in graphs and tables. The vapor-cycle ECS is shown to give superior performance in all evaluation categories at all altitudes up to 15,000 ft; the lift penalties for bleed-air, compressor, and vapor-cycle ECSs are given as 1497, 776, and 401 lbs, respectively. T.K.

**A85-41133\*** Michigan Univ., Ann Arbor.

### **HEAT GENERATION IN AIRCRAFT TIRES**

S. K. CLARK and R. N. DODGE (Michigan, University, Ann Arbor) (George Washington University and NASA, Symposium on Advances and Trends in Structures and Dynamics, Washington, DC, Oct. 22-25, 1984) Computers and Structures (ISSN 0045-7949), vol. 20, no. 1-3, 1985, p. 535-544. Research supported by the University of Michigan and NASA. Previously announced in STAR as N83-21400. refs

A method was developed for calculating the internal temperature distribution in an aircraft tire while free rolling under load. The method uses an approximate stress analysis of each point in the tire as it rolls through the contact patch, and from this stress change the mechanical work done on each volume element may be obtained and converted into a heat release rate through a knowledge of material characteristics. The tire cross-section is then considered as a body with internal heat generation, and the diffusion equation is solved numerically with appropriate boundary conditions of the wheel and runway surface. Comparison with data obtained with buried thermocouples in tires shows good agreement. Author

**A85-41398**

### **DESCENDING FLIGHT AND ITS OPTIMIZATION [BETRACHTUNGEN ZUM SINKFLUG UND ZU SEINER OPTIMIERUNG]**

M. CASPARI and S. KINDLER (Interflug Gesellschaft fuer Internationalen Flugverkehr mbH, Berlin, East Germany) Technisch-ökonomische Information der zivilen Luftfahrt (ISSN 0232-5012), vol. 21, no. 2, 1985, p. 55-58, 67, 74. In German.

The theory of descending flight is reviewed, and techniques for computing the optimal velocity profile for a given combination of aircraft mass and flight characteristics, wind conditions, and

flight path are discussed. The optimization criterion is cost, so that the costs for fuel (minimized by slow descent over a long distance) and time (minimized by short rapid descent) must be balanced. Typical profiles are shown in graphs, and recommendations for the types of aircraft used by Interflug are included. T.K.

**A85-41528**

### **WILL ROTORS LOSE THEIR BEARINGS?**

G. WARWICK Flight International (ISSN 0015-3710), vol. 127, June 29, 1985, p. 30-35.

After discussing the design practices by means of which conventional helicopter rotor hub designs have attempted to mediate among powerful and conflicting aerodynamic, inertial and centrifugal forces, at the expense of considerable complexity, attention is given to the development history and current status of techniques by which rotor hub structures can be simplified and lightened. Simplification, often achieved through the application of elastomeric and anisotropic composite materials, is noted to have as one of its primary benefits a significant reduction of maintenance requirements and an enhancement of reliability. Design details are explored in the cases of the 'double beam' and 'single beam' bearingless main rotor hubs, and the 'dynaflex' gimballed rotor hub. O.C.

**A85-41531**

### **DASH 8 - MADE FOR THE NEW COMMUTER MARKET**

J. CLOSTERMANN Interavia (ISSN 0020-5168), vol. 40, July 1985, p. 771-774.

An evaluation is made of the commercial prospects of the Dash 8 twin turboprop commuter airliner, in view of such performance characteristics as payload-range efficiencies and pilot control refinements over those of aircraft for comparable applications. The Dash 8's pressurized cabin accommodates 36 passengers. Attention is given to the flight control hydraulic systems and the flight qualities experienced during flight testing by the pilot at the controls. O.C.

**A85-41533**

### **FIRST HAVOC, NOW HOKUM - WHAT ROLE FOR THE NEW SOVIET HELICOPTER?**

M. LAMBERT Interavia (ISSN 0020-5168), vol. 40, July 1985, p. 798, 799.

A preliminary analysis is conducted of the Soviet Union's new military helicopter, NATO-codenamed 'Hokum'. Most noticeable among the configurational features of this aircraft are contrarotating rotors, which obviate the use of a torque-counteracting tail rotor. These features lead to the speculation that this high speed, long operational radius design makes use of Advancing Blade Concept aerodynamics, which require the mastery of ultrarigid rotor blade structure technology, and that it is the product of a design competition between the Mil design bureau and that of Kamov, which has had sole responsibility to date for counterrotation rotor system-based naval helicopter designs. O.C.

**A85-41539**

### **GULFSTREAM - VERSATILITY THROUGH CONCENTRATION**

Air International (ISSN 0306-5634), vol. 29, July 1985, p. 10-17.

A development history and a discussion of design features and performance capabilities are presented for the civilian, paramilitary and military variants derived from the Gulfstream III 'bizjet'. Attention is given to the surveillance instruments suite of the Gulfstream III variant designated 'SRA-1' and designed as a reconnaissance platform, which encompasses side-looking and synthetic aperture radars, a panoramic camera, a long range oblique photography camera, and electronic surveillance and submarine detection equipment. Four alternative primary missions are contemplated: high altitude reconnaissance, electronic surveillance, maritime patrol, and antisubmarine warfare. O.C.



A85-41540

**PEACE JACK - AN ENIGMA EXPOSED**

Air International (ISSN 0306-5634), vol. 29, July 1985, p. 18-23.

A development history and a discussion of design modification effects on performance capabilities are presented for the family of RF-4 ('Phantom II') reconnaissance aircraft whose development was collectively designated 'Peace Jack'. Extensive propulsion system modifications were prompted by the severe degradation of speed and altitude performance by the drag incurred by the heavy, ultralong focal length Long Range Oblique Photography camera system known as 'HIAC-1'. The propulsion system modifications by which the requisite Mach 2.4/78,000-ft altitude regime was regained involved the redesign of the engine air intakes and the use of water spray cooling for the intake air column.

O.C.

A85-41605

**A DISCRETE MODEL FOR THE ANALYSIS OF NATURAL VIBRATIONS OF A DEFORMABLE AEROPLANE**

Z. DZYGADLO, I. NOWOTARSKI, and A. OLEJNIK Journal of Technical Physics (ISSN 0324-8313), vol. 25, no. 2, 1984, p. 177-189. refs

An analytical method is proposed to investigate the vibration frequencies and natural vibration modes of a deformable fixed wing aircraft. The method is based on a one-dimensional discretization of deformable structural assemblies (bars and rigid bodies) using a finite element method (FEM). The model can also be used to analyze the dynamic characteristics of any deformable structure which is discretized by a system of bars and rigid bodies. The stiffness and mass matrices of a bar structure are given.

I.H.

A85-41607

**NUMERICAL ANALYSIS OF THE DYNAMIC CHARACTERISTICS OF A HELICOPTER ROTOR BLADE WITH VARIOUS BOUNDARY CONDITIONS**

W. SOBIERAJ Journal of Technical Physics (ISSN 0324-8313), vol. 25, no. 2, 1984, p. 207-227. refs

An algorithm and computer program for numerical analysis of the dynamic characteristics of helicopter rotor blades have been developed, based on the finite element method. The program can be used to determine the effect of each structural parameter of the blade, the hub arm of the rotor, and the blade angle control system, on the resonance characteristics of the blade and the hub arm. Examples of the numerical results obtained using the computer program are discussed. The computer program written in FORTAN, is given in another paper.

I.H.

A85-41730

**STRUCTURAL INTEGRITY OF HELICOPTERS IN RELATION TO THEIR AIRWORTHINESS**

J. W. BRISTOW (Civil Aviation Authority, London, England) International Journal of Aviation Safety (ISSN 0264-6803), vol. 3, June 1985, p. 118-122. refs

Britain's Civil Aviation Authority (CAA) has examined the implications for airworthiness of the increasing application of composite materials to helicopter airframe primary structures. Attention is presently given to methods of damage tolerance substantiation for the cases of both fatigue and impact damage. Composite materials can exhibit significantly improved fatigue strengths in relation to ultimate static strength, so that adequate fatigue strength demonstration does not imply static strength margins. Attention is also given to events related to fatigue or mechanical failure on large transport helicopters which have directly involved the CAA's Airworthiness Division.

O.C.

A85-41916

**THE ATR 72 - DESIGN AND PERFORMANCE FEATURES [L'ATR 72 - CARACTERISTIQUES ET PERFORMANCES]**

J. MORISSET Air et Cosmos (ISSN 0044-6971), vol. 23, June 29, 1985, p. 20, 22, 23, 25, 26. In French.

The turboprop powered commuter aircraft ATR 72, intended for 1988 service, is being developed to lower the cost per

passenger mile compared to its predecessor, the ATR 42. A stretch version of the ATR 42, the ATR 72 will have 66-74 seats, wings increased from a 24.57 m to a 27.05 m span, and an empty takeoff weight of 19.99 tons, compared to 16.15 tons for the ATR 42. Wind tunnel tests have fixed the wing geometry. The same propeller will be used for the present PW 124 engine, although the nacelle will be altered. Extensive use will be made of composite materials, and attempts will be made to keep a maximum commonality of primary structures and avionics between the two aircraft. The ATR 72 is to take off from a 1390 m runway, have a 284 kt cruise speed, and fly a 900 n.mi. range with 66 passengers. Landings will be handled by a 1045 m runway.

M.S.K.

A85-41917

**THE FIRST INTELLIGENT AIRCRAFT [LE PREMIER AVION INTELLIGENT]**

Air et Cosmos (ISSN 0044-6971), vol. 23, July 6, 1985, p. 15, 16, 19 (3 ff.). In French.

The avionics, control, navigation, flight state and sensor systems of the Airbus 320 will feature state of the art components, provided that they have been proven in-service. A mini-grip joystick to the side of the pilot will be the primary innovation. Instrument displays will be replaced by six CRT displays, each being configured for specific flight phases and responsive to flight management and T/CAS inputs. Each sensor, microprocessor and screen will have redundancy. All flight controls are to be fly-by-wire, activating the hydraulic control systems. There will be no mechanical back-up. New model engines will also be electronically controlled. Five computers will handle all flight functions and have sufficiently redundant and distributed architecture to project a zero probability of failure in any primary control system. Power will be supplied by a 24 krpm generator.

M.S.K.

A85-42124

**STRENGTH ANALYSIS OF AIRCRAFT [RASHCHET SAMOLETA NA PROCHNOST']**

V. M. STRIGUNOV Moscow, Izdatel'stvo Mashinostroenie, 1984, 376 p. In Russian. refs

Traditional analytical methods of the strength analysis of aircraft are reviewed, with particular attention given to the determination of the strength of the airtight compartments and fuselages of modern aircraft allowing for various openings in the structures and stability loss in fuselage and wing panels. Recommendations are included on the strength analysis of multiple-deck wide-body aircraft and variable-sweep wings. The discussion also covers the fatigue of aircraft and methods for predicting the service life of aircraft and individual aircraft components.

V.L.

A85-42664#

**ONBOARD SIMULATION - A NEWLY EMERGING TECHNOLOGY AND THE POTENTIAL OF THE HELMET MOUNTED DISPLAY AS AN EMBEDDED TRAINING DEVICE**

R. E. LAMBERT, R. P. MEYER (McDonnell Aircraft Co., St. Louis, MO), B. J. BRADY, and S. K. NORTON (USAF, Wright Aeronautical Laboratories, Wright-Patterson AFB, OH) AIAA, Flight Simulation Technologies Conference, St. Louis, MO, July 22-24, 1985. 7 p. (Contract F33615-78-C-3601)

(AIAA PAPER 85-1737)

The enhanced Onboard Simulation effort within the U.S. Air Force's Integrated Flight/Fire Control program has been undertaken to extend air-to-air engagement mode simulations, to perform a tradeoff study which would compare the cost effectiveness of this and other forms of pilot training, and to conduct a manned simulation to determine the utility of a helmet-mounted display in onboard simulations. The Helmet-Mounted Sight/Display system employed was outfitted with a magnetic position sensor which provided helmet line-of-sight information through the 360 deg of a sphere. Attention is given to the helmet mounted display's graphics symbology and the target maneuvers undertaken by the present investigation.

O.C.

## 05 AIRCRAFT DESIGN, TESTING AND PERFORMANCE

**A85-42670#**

### **ADVANCED PROPULSION THROUGH THE 1990S - AN AIRFRAMER'S VIEW**

S. A. E. MANN and C. A. STUART (Airbus Industrie, Blagnac, France) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 10 p. (AIAA PAPER 85-1192)

This paper reviews the current engine scene and looks into the crystal ball to examine the potential and applications of advanced high bypass ratio powerplants in future civil use. The paper concentrates on the short/medium haul category of airliners of more than 120 seats with a cruise Mach Number of 0.75 or greater. Although emphasis is placed on the airframe aspects, some engine questions are addressed. The certification aspects are seen as a critical element in the development of open rotor powered aircraft. Fuel burn reductions of up to 25 percent are foreseen at Mach Numbers in the range 0.75-0.8 although several factors reduce the effect of this in the operating costs of an airline. Time-scales are shown that lead to the entry into service of the next generation powerplants, on first line civil aircraft of the size category discussed, in the second half of the nineties. Ducted advanced propulsion systems are briefly discussed and seen to require careful consideration. Author

**A85-42677#**

### **THE AIRBUS A 310-300 AS AN EXAMPLE OF THE CONSTRUCTION OF AN FRP VERTICAL TAIL FIN [KONSTRUKTION EINES FASERVERBUND-SEITENLEITWERKES AM BEISPIEL DES AIRBUSSES A310-300]**

H. BRENNIS (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, West Germany) VDI, Tagung ueber Konstruieren mit Verbund- und Hybridwerkstoffen, Fellbach, West Germany, May 7, 8, 1985, Paper. 16 p. In German. (MBB-UT-52-85-OE)

The design and manufacture of the CFRP central section of the vertical tail fin for the A 310-300 are described and illustrated with drawings and diagrams. The central section is the main load-bearing component of the vertical fin and comprises two side panels, three spar webs, nine fully laminated ribs, nine channel ribs, and seven rudder-bearing mounts. The specialized fabrication techniques used for each component are explained, and consideration is given to assembly (using Hi-Lok rivets) and the incorporation of metal parts in the CFRP structure. CFRP construction is shown to reduce the number of parts from 2072 to 96 and the weight by 25 percent, as compared with an Al-alloy version. T.K.

**A85-42685#**

### **APPLICATION OF COMPUTER-AIDED STRUCTURAL OPTIMIZATION IN THE DESIGN OF AIRCRAFT COMPONENTS [ANWENDUNG DER RECHNERGESTUETZTEN STRUKTUROPTIMIERUNG BEI DER AUSLEGUNG VON FLUGZEUGBAUTEILEN]**

H. WELLEN (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) DGLR, Fachausschussitzung ueber Festigkeit und Bauweisen, Neubiberg, West Germany, May 7, 1984, Paper. 7 p. In German. refs

(MBB-UT-21-84-OE)

In the aerospace industry, the minimization of the structural weight is one of the vital requirements for an economic design of flight vehicles. A computer-aided structural optimization procedure can provide possibilities for performing a weight-optimal dimensioning of structural members in an automatized form, taking into account the employment of programmed, mathematical methods. It is possible to achieve the weight optimum under conditions involving time and cost advantages in comparison to the conventional design process. The Royal Aircraft Establishment (RAE) in England has developed the Structural Analysis and Redesign System (Stars) for a computer-aided structural optimization. Stars makes it possible to solve the involved mathematical problem with the aid of various optimization methods. A description is presented of the modular design of Stars and its

operation. The practical application of Stars is discussed, taking into account the solution of design problems related to the Airbus A 310. Attention is given to calculations based on a simplified finite-element model. G.R.

**A85-42895#**

### **AVTEK 400 - LIGHT IS RIGHT**

R. DEMEIS Aerospace America (ISSN 0740-722X), vol. 23, Aug. 1985, p. 62-64, 66.

The necessity of stimulating new business in the market for twin-turboprop aircraft is being met by the development of innovative designs which offer significant operating economies and enhanced performance. Composite components are being extensively used and are accompanied by claims of up to 40 percent fuel savings on the basis of reduced weight. The Avtek 400 is nearing the full-scale prototype stage. The 400 features a Kevlar aramid fiber structure except in areas requiring greater stiffness, where graphite reinforced composites and other hybrids are employed. The aircraft comprises 62 molded parts, which represents substantial labor savings in assembly. The structures have an effectively infinite number of load paths, the effects of which became apparent during a wheels-up landing that left the aircraft intact during tests. Repairs were cheap. The 400 is 34 ft long, will carry 6-10 passengers, has 15.5 deg swept wings, canards over and behind the cockpit, PT-6 engines, and will fly at 400 mph burning 10 mpg for a 2600 mi range. M.S.K.

**A85-42897#**

### **SUPERCUISE FOR A STOL DOGFIGHTER**

D. P. RAYMER (Rockwell International Corp., Pittsburgh, PA) Aerospace America (ISSN 0740-722X), vol. 23, Aug. 1985, p. 72-75.

Aircraft aerodynamic design options exist for producing fighters with supersonic cruise speeds, thus eliminating the necessity of going to fuel-inefficient afterburners to reach top speeds. The design goal for a 1990s replacement for the F-15 is to reduce supersonic wave drag. A near-delta wing, minimal areal variation from head-to-tail, relaxed static stability and no horizontal rudder can help achieve the goals. Engine inlets are positioned to avoid inhalation of shock waves and are under the wing, which improves inlet operation at high angles of attack. The 15 percent negative stability of the aircraft necessitates a computerized flight control system. Finally, fine design points defined using computational methods are discussed. M.S.K.

**A85-42930#**

### **THE DETERMINATION OF OPTIMUM FLIGHT PROFILES FOR SHORT-HAUL ROUTES**

D. SIMOS and L. R. JENKINSON (Loughborough University of Technology, England) Journal of Aircraft (ISSN 0021-8669), vol. 22, Aug. 1985, p. 669-674. Research supported by Short Brothers, Ltd., and SERC. Previously cited in issue 03, p. 5, Accession no. A85-13515. refs

**A85-42932#**

### **EXPERIMENTAL AEROELASTIC BEHAVIOR OF UNSWEPT AND FORWARD-SWEPT CANTILEVER GRAPHITE/EPOXY WINGS**

B. J. LANDSBERGER (USAF, Edwards AFB, CA) and J. DUGUNDJI (MIT, Cambridge, MA) (Structures, Structural Dynamics and Materials Conference, 25th, Palm Springs, CA, May 14-16, 1984, and AIAA Dynamics Specialists Conference, Palm Springs, CA, May 17, 18, 1984, Technical Papers. Part 2, p. 589-598) Journal of Aircraft (ISSN 0021-8669), vol. 22, Aug. 1985, p. 679-686. Previously cited in issue 13, p. 1915, Accession no. A84-31749. refs

(Contract AF-AFOSR-82-0071)

A85-42933#

**RISK ASSESSMENT OF AN AGING MILITARY AIRCRAFT**

J. W. LINCOLN (USAF, Aeronautical Systems Div., Wright-Patterson AFB, OH) Journal of Aircraft (ISSN 0021-8669), vol. 22, Aug. 1985, p. 687-691.

(AIAA PAPER 84-0851)

The paper examines the adequacy of the U.S. Air Force damage tolerance inspection criterion for protecting the safety of the flight of an aging military trainer aircraft. This is done through a risk assessment based on cracks found in teardown inspections of retired wings. The crack population is combined with stress probabilities representing service experience to determine single flight probability of failure and the single aircraft probability of failure after a given time. These quantities are then used as a basis for judging the required inspection interval. For the case studied, the 0.9 probability of detection inspection criterion in the Air Force damage tolerance requirements may be unconservative.

Author

A85-42939#

**APPROACH TO INTERIOR NOISE CONTROL II  
SELF-SUPPORTING DAMPED INTERIOR SHELL**

C. I. HOLMER (Cabot Corp., Indianapolis, IN) Journal of Aircraft (ISSN 0021-8669), vol. 22, Aug. 1985, p. 729-733. Previously cited in issue 01, p. 4, Accession no. A85-10901. refs

A85-43222

**STATIC TEST TECHNIQUES FOR COMPOSITE AIRFRAME  
STRUCTURES DEVELOPED ON THE U.S. ARMY/SIKORSKY  
ACAP**

H. L. KEARNEY (United Technologies Corp., Sikorsky Aircraft Div., Stratford, CT) and D. GOOD (U.S. Army, Applied Technology Laboratory, Ft. Eustis, VA) American Helicopter Society, Journal (ISSN 0002-8711), vol. 30, July 1985, p. 43-52.

Special considerations and test techniques used during static testing of the U.S. Army/Sikorsky Advanced Composite Airframe Program (ACAP) airframe are discussed. Included are considerations for accountability for the effects of prolonged environmental exposure on composite material strength, and establishment of limit and ultimate load pass/fail criteria. Techniques used for damage detection and inspections, and the problems and solutions associated with repairing bonded composite structures damaged during test conduct are described.

Author

A85-43223\* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**THRUST CHANGES INDUCED BY GROUND AND CEILING  
PLANES ON A ROTOR IN HOVER**

V. J. ROSSOW (NASA, Ames Research Center, Moffett Field, CA) American Helicopter Society, Journal (ISSN 0002-8711), vol. 30, July 1985, p. 53-55. refs

The thrust produced by a helicopter motor in hover has been studied by measuring the thrust on a model rotor 0.234 meters in diameter operating between ground and ceiling planes. The distance between the two planes and the rotor disk was in the range 0.08-6.0 rotor diameters. It was found that the confining surfaces changed the rotor thrust almost linearly with the logarithm of the distance from the confining surface. When both planes were near the rotor the variation was no longer linear. The measured thrust of the rotor was compared to predictions based on the theoretical calculations of Rossow (1985), and the results are given in a table.

I.H.

A85-43225

**INTERACTIVE COMPUTER MODELING OF AIRFRAME  
STRUCTURES**

B. P. JOHNSTON and M. S. SHEPHARD (Rensselaer Polytechnic Institute, Troy, NY) American Helicopter Society, Journal (ISSN 0002-8711), vol. 30, July 1985, p. 59-61.  
(Contract DAAG29-82-K-0093)

A method for the interactive definition of structural models for helicopter airframes is proposed. The goal of the method is to simplify and speed up the process of generating structural models

which are suited to finite element analysis. The modeling approach consists of three separate tasks: defining the outer contours of the aircraft, defining structural components, and detailing structural components. It is shown that the development of structural models according to the above method can substantially reduce the time required to generate numerical models for airframe analysis. The need for a finite element method which is interactive with respect to structural models is also discussed.

I.H.

A85-43241#

**REQUIREMENTS AND DESIGN METHOD FOR MATCHING  
AIRCRAFT GUNS WITH THEIR SUPPORTING STRUCTURE**

L. HE and P. ZHAO (Shengyang Aircraft Corp., People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Feb. 1985, p. 21-28. In Chinese, with abstract in English. refs

In aircraft structural dynamic design the matching of the guns with their supporting structure is one of the most important tasks on which hinges the success or failure of the structural design. The design curves for matching the guns with their supporting structure can be obtained from the response calculation of the plate-spring system supporting the gun on the ground, the model structure tested on the ground and the actual structure. A set of matching curves is given for engineering application. Then, the matching design can be accomplished by means of impact load spectrograms so as to perform the optimal structural design and to make further improvement on dynamic strength program.

Author

A85-43242#

**QUICK GEOMETRY GENERATION AND SURFACE MESH  
PARTITION FOR ARBITRARY 3-D BODIES**

Z. TANG, A. LI, and S. CAO (Chengdu Aeronautical Co., People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Feb. 1985, p. 29-37. In Chinese, with abstract in English. refs

A method for the surface fitting of three-dimensional bodies is presented in this paper. The longitudinal lofting curves are a chain of conics generated by least square fitting, whereas cross-sectional curves are hybrid blended conics which contain circular arcs, elliptic arcs, and straight lines. A FORTRAN program involving computer graphics on the SIEMENS 7.760 computer has been written. The program is capable of quick and handy generation of the complicated configuration of 3-D bodies and surface meshes required in the aerodynamic influence coefficient method. The applicability and validity are verified by some numerical examples. Further development of the program enables it to be a graphic master dimensional system for computer-aided design.

Author

N85-29947\* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**AIRCRAFT ROTOR BLADE WITH PASSIVE TUNED TAB  
Patent**

T. G. CAMPBELL, inventor (to NASA) (Sikorsky Aircraft, Stratford, Conn.) 30 Apr. 1985 10 p Filed 28 Apr. 1983 Sponsored by NASA

(NASA-CASE-ARC-11444-1; US-PATENT-4,514,143;  
US-PATENT-APPL-SN-489675; US-PATENT-CLASS-416-23;  
US-PATENT-CLASS-416-145; US-PATENT-CLASS-416-500)  
Avail: US Patent and Trademark Office CSCL 01C

A structure for reducing vibratory airloading in a rotor blade with a leading edge and a trailing edge includes a cut out portion at the trailing edge. A substantially wedge shaped cross section, inertially deflectable tab, also with a leading edge and a trailing edge is pivotally mounted in the cut out portion. The trailing edge of the tab may move above and below the rotor blade. A torsion strap applies force against the tab when the trailing edge of the tab is above and below the rotor blade. A restraining member is slidably movable along the torsion strap to vary torsional biasing force supplied by the torsion bar to the tab. A plurality of movable weights positioned between plates vary a center of gravity of the tab. Skin of the tab is formed from unidirectional graphite and fiberglass layers. Sliders coupled with a pinned degree of freedom at rod eliminate bending of tab under edgewise blade deflection.

Official Gazette of the U.S. Patent and Trademark Office

## 05 AIRCRAFT DESIGN, TESTING AND PERFORMANCE

**N85-29948** Texas A&M Univ., College Station.  
**ELECTROOCULOGRAPHIC MEASUREMENT, FATIGUE AND VARIABILITY OF PERFORMANCE IN SIMULATED AIRCRAFT FLIGHT** Ph.D. Thesis

T. L. MORRIS 1984 170 p

Avail: Univ. Microfilms Order No. DA8504702

Several components of eye and eyelid movement were examined using the electrooculogram (EOG) as the measurement technique. The intent was to determine whether four specific eye movement measures could be used as predictors of the subtle performance decrements due to flying related fatigue. It was also intended to determine whether subjective fatigue changes and performance decrement could be detected in tasks similar to typical Air Force pilot duty days. Fatigue was measured with pre- and post-flight subjective scales and an error scoring method which scored the variability of performance (standard deviation) weighted by accuracy (mean error). The results of the day analyses were that: (1) the variability based error score was more sensitive to performance decrements other measures; (2) the subjective fatigue measures indicated a significant increase in fatigue over time and were positively correlated with the performance measure; (3) blink rate was the best predictor of performance decrements for tracking; (4) long eye closure rate was the best predictor for the monitoring segments; (5) blink duration was a less significant predictor in both tasks, and (6) horizontal saccade velocity was not a significant predictor in either task segment. Dissert. Abstr.

**N85-29949\*** Douglas Aircraft Co., Inc., Long Beach, Calif.  
**DC-10 WINGLET FLIGHT EVALUATION Final Report, Aug. 1980 - Apr. 1982**

Washington NASA Jun. 1983 145 p refs

(Contract NAS1-15327)

(NASA-CR-3704; NAS 1.26:3704; ACEE-17-FR-2756A) Avail:

NTIS HC A07/MF A01 CSCL 01C

The results of a flight evaluation of winglets on a DC-10 Series 10 aircraft are presented. For sensitive areas of comparison, effects of winglets were determined back to back with and without winglets. Basic and reduced span winglet configurations were tested. After initial encounter with low speed buffet, a number of acceptable configurations were developed. For maximum drag reduction at both cruise and low speeds, lower winglets were required, having leading edge devices on upper and lower winglets for the latter regime. The cruise benefits were enhanced by adding outboard aileron droop to the reduced span winglet aircraft. Winglets had no significant impact on stall speeds, high speed buffet boundary, and stability and control characteristics. Flutter test results agreed with predictions and ground vibration data. Flight loads measurement also agreed with predictions. Author

**N85-29950\*** Douglas Aircraft Co., Inc., Long Beach, Calif.  
**FLIGHT-SERVICE PROGRAM FOR ADVANCED COMPOSITE RUDDERS ON TRANSPORT AIRCRAFT Annual Summary Report, 1 Jun. 1978 - 30 Jun. 1979**

Jul. 1979 33 p refs

(Contract NAS1-12954; NAS1-14724)

(NASA-CR-174537; NAS 1.26:174537; ASR-3) Avail: NTIS HC A03/MF A01 CSCL 01C

Flight service experience and in-service inspection results are reported for DC-10 graphite composite rudders during the third year of airline service. Test results and status are also reported for ground-based and airborne graphite-epoxy specimens with three different epoxy resin systems to obtain moisture absorption data. Twenty graphite composite rudders were produced, nine of which were installed on commercial aircraft during the past three years. The rudders collectively accumulated 75,863 flight hours. The high time rudder accumulated 12,740 flight hours in slightly over 36 months. The graphite composite rudders were inspected visually at approximately 1000 flight hour intervals and ultrasonically at approximately 3000 flight hour intervals in accordance with in-service inspection plans. All rudders were judged acceptable for continued service as a result of these inspections. Composite moisture absorption data on small specimens, both ground-based and carried aboard three flight-service aircraft, are given. The

specimens include Thorne 300 fibers in Narmco 5208 and 5209 resin systems, and Type AS fibers in the Hercules 3501-6 resin system. R.J.F.

**N85-29852#** Air Force Inst. of Tech., Wright-Patterson AFB, Ohio. School of Engineering.

**APPLICATION OF FLOQUET THEORY TO HELICOPTER BLADE FLAPPING STABILITY** M.S. Thesis

J. K. MARCH Dec. 1984 212 p

(AD-A154460; AD-E950702; AFIT/GAE/AA/84D-13) Avail:

NTIS HC A10/MF A01 CSCL 01C

The purpose of this thesis was to explore the flapping stability of a helicopter rotor blade in forward flight. The equations of motion for the flapping motion for the flapping motion of the blade were converted from nonlinear differential equations with periodic coefficients to linear periodic differential equations through the assumption of a rigid blade where the elastic flapping deflections are negligible as compared to the rigid body flapping rotations about the flapping hinge. Aeroelastic effects were not considered. The stability of the homogenous part of the flapping motion linearized periodic differential equations was examined through the application of Floquet theory. The flapping blade motion was simulated over one period to derive the elements of the monodromy matrix. The monodromy matrix was next transformed into Jordan normal form through a similarity transformation to obtain its characteristic values and eigenvectors. The characteristic values were converted to their respected Poincare' exponents and the periodic eigenvectors composition was determined and transformed into Fourier series representations. A feedback controller was constructed using Floquet theory for the unstable blade flapping motion case. GRA

**N85-31044\*** Washington Univ., St. Louis, Mo. Dept. of Mechanical Engineering.

**DESIGN OF HELICOPTER ROTOR BLADES FOR OPTIMUM DYNAMIC CHARACTERISTICS** Final Report, 17 Jan. 1982 - 17 Jan. 1985

D. A. PETERS, T. KO, A. KORN (Univ. of Southern Illinois, Edwardsville), and M. P. ROSSOW (Univ. of Southern Illinois, Edwardsville) 17 Jan. 1985 116 p refs

(Contract NAG1-250)

(NASA-CR-176076; NAS 1.26:176076) Avail: NTIS HC A06/MF A01 CSCL 01C

The mass and stiffness distributions for helicopter rotor blades are tailored in such a way to give a predetermined placement of blade natural frequencies. The optimal design is pursued with respect of minimum weight, sufficient inertia, and reasonable dynamic characteristics. Finite element techniques are used as a tool. Rotor types include hingeless, articulated, and teetering. Author

**N85-31045\*** Advanced Rotorcraft Technology, Inc., Mountain View, Calif.

**ESTIMATION OF DYNAMIC ROTOR LOADS FOR THE ROTOR SYSTEMS RESEARCH AIRCRAFT: METHODOLOGY DEVELOPMENT AND VALIDATION**

R. W. DUVAL and M. BAHRAMI May 1985 56 p refs

(Contract NAS2-11688)

(NASA-CR-177362; T47130; NAS 1.26:177362) Avail: NTIS HC A04/MF A01 CSCL 01C

The Rotor Systems Research Aircraft uses load cells to isolate the rotor/transmission system from the fuselage. A mathematical model relating applied rotor loads and inertial loads of the rotor/transmission system to the load cell response is required to allow the load cells to be used to estimate rotor loads from flight data. Such a model is derived analytically by applying a force and moment balance to the isolated rotor/transmission system. The model is tested by comparing its estimated values of applied rotor loads with measured values obtained from a ground based shake test. Discrepancies in the comparison are used to isolate sources of unmodeled external loads. Once the structure of the mathematical model has been validated by comparison with experimental data, the parameters must be identified. Since the

parameters may vary with flight condition it is desirable to identify the parameters directly from the flight data. A Maximum Likelihood identification algorithm is derived for this purpose and tested using a computer simulation of load cell data. The identification is found to converge within 10 samples. The rapid convergence facilitates tracking of time varying parameters of the load cell model in flight. Author

**N85-31046#** Societe Nationale Industrielle Aerospatiale, Toulouse (France). Direction Etudes.  
**DESIGN OF THE NACELLE FOR THE A-320 AIRCRAFT**  
**[CONCEPTION DE LA NACELLE A-320]**

D. GISQUET 18 Feb. 1985 30 p. In FRENCH Presented at 21st Colloq. Aerodyn. Appl. (AAAF), Lyon, 7-9 Nov. 1984 (SNIAS-851-111-111) Avail: NTIS HC A03/MF A01

The definition of targets and requirements for A-320 nacelle flow lines, the definition of nacelle shape through subsonic and transonic computations, and the checkout through wind tunnel tests are described. The study of the air inlet and the flow around the nacelle is detailed. A three-dimensional singularities method and a finite element method were used in the computation. The test results of the air inlet design agree with the specifications. Author (ESA)

**N85-31047#** Societe Nationale Industrielle Aerospatiale, Marignane (France). Helicopter Div.  
**A NEW MAIN ROTOR HUB FOR THE AS 332 SUPER PUMA**

R. MOUILLE and C. BIETENHADER 1985 9 p Presented at 10th European Rotorcraft Forum, The Hague, 28-31 Aug. 1984 (SNIAS-851-210-102) Avail: NTIS HC A02/MF A01

A light, economical, helicopter rotor head was developed to reduce weight and drag. For the metal version for the AS 332 Super Puma, which is interchangeable with the production rotor head, without modifications of the upper aircraft cowlings, gains are less marked, particularly with respect to drag. A weight reduction of about 65 kg is obtained, the number of parts is reduced by 3, and safety is considerably improved owing to the redundancy in the central part of the hub which gives it fail-safe properties. Author (ESA)

**N85-31048#** Societe Nationale Industrielle Aerospatiale, Marignane (France). Airworthiness and Certification Dept.  
**STANDARDIZATION OF HELICOPTER CERTIFICATION REQUIREMENTS IN THE WESTERN WORLD**

H. PORTET 1984 8 p Presented at 10th European Rotorcraft Forum, The Hague, 28-31 Aug. 1984 (SNIAS-851-210-103) Avail: NTIS HC A02/MF A01

European cooperation in drawing up airworthiness codes is reviewed and the need to extend this to the helicopter industry is stressed. Regulations for the power transmission system endurance test, takeoff, and engine power ratings are discussed. Author (ESA)

**N85-31049#** Societe Nationale Industrielle Aerospatiale, Marignane (France). Helicopter Div.  
**AUTOMATED FABRICATION OF COMPOSITE STRUCTURES FOR HELICOPTERS**

G. BEZIAC and C. FRANCHI 1984 14 p refs Presented at 10th European Rotorcraft Forum, The Hague, 28-31 Aug. 1984 (SNIAS-851-210-104) Avail: NTIS HC A02/MF A01

Automated fabrication of helicopter secondary structures, stressed primary structures, single piece components, and thermoplastic components is described. Optimization of use of prepreps; handling and transfer of cutouts; draping; cutting of laminates; and winding, braiding, and weaving are discussed. Author (ESA)

**N85-31050#** Societe Nationale Industrielle Aerospatiale, Marignane (France). Helicopter Div.

**RESEARCH FLIGHT SIMULATOR FOR HELICOPTERS (RFSH): DESCRIPTION AND APPLICATION TO FIRE CONTROL SYSTEM DESIGN**

C. HECKETSWEILER 1984 8 p Presented at 10th European Rotorcraft Forum, The Hague, 28-31 Aug. 1984 (SNIAS-851-210-106) Avail: NTIS HC A02/MF A01

A helicopter flight simulator consisting of a cabin with conventional instrumentation, cathode-ray tube and four axis flight controls; an outside environment visual system; an acceleration and vibrations simulation system; a noise generation system; and computers with real time software was built. It was used in the design of an air-to-air combat helicopter system. Piloted simulations included adjustment of the controls and the symbologies; adjustment of the fire sequence and evaluation of its practical feasibility (crew workload); evaluation of the interactions between fire control and flight control; and study of the system's operation in back-up modes. Author (ESA)

**N85-31051#** Societe Nationale Industrielle Aerospatiale, La Courneuve (France).

**THE HELICOPTER, INSTRUMENT OF CHOICE FOR HEALTH EVACUATION [L'HELICOPTERE, INSTRUMENT D'ELECTION POUR L'EVACUATION SANITAIRE]**

20 Dec. 1984 12 p In FRENCH Submitted for publication (SNIAS-851-220-101) Avail: NTIS HC A02/MF A01

The advantages of the use of helicopters for the evacuation and transportation of persons in danger, injured, or with severe health problems are discussed. The transport time reduction is reduced by a factor of 4 to 5 times when using the Dauphin SA-365N helicopter compared to surface transportation. The economic justification and the effectiveness in saving human lives are analyzed. Author (ESA)

**N85-31053#** European Space Agency, Paris (France).  
**FLIGHT-MECHANICS TEST WITH A RESTRICTED FLYING AIRCRAFT MODEL IN A WIND TUNNEL**

H. SUBKE Jan. 1985 151 p refs Transl. into ENGLISH of "Beitr. zur Versuchsmethodik fuer Flugmech. Untersuch. mit dyn. aehnlichen Flugzeugmodellen im Windkanal", Brunswick, Rept. DFVLR-FB-84-13, 1984 Original language doc. previously announced as N84-27701

(ESA-TT-885; DFVLR-FB-84-13) Avail: NTIS HC A08/MF A01; original German version available from DFVLR, Cologne DM 45

A wind tunnel test of a dynamically scaled aircraft model equipped with sensors and actuators is presented. The dynamic response was compared with the result of a computer simulation. A good correlation is obtained after adjustment of the dynamic derivatives. The natural dynamic behavior of the model was changed in order to simulate different aircraft in different missions. Author (ESA)

**N85-31054#** European Space Agency, Paris (France).  
**DESIGN OF A BASIC AIRFOIL FOR A SLIGHTLY SWEEP WING. PART 1: THEORETICAL TRANSONIC AIRFOIL DESIGN**

G. WICHMANN Feb. 1985 50 p refs Transl. into ENGLISH of "Entwurf eines Basisprofils fuer einen schwach gepfeilten Tragfluegel. Teil 1: Theoret. Profilentwurf fuer den transsonischen Geschwindigkeitsber." Brunswick, Rept. DFVLR-FB-84-19, 1984 Original language doc. previously announced as N85-12043 (ESA-TT-892; DFVLR-FB-84-19) Avail: NTIS HC A03/MF A01; original German version available from DFVLR, Cologne DM 15.50

A wing based on the A-300 aircraft with leading edge sweep reduced from 30 to 13.5 deg at the same flight Mach number was designed using transonic wing technology. A method based on the complete potential flow equation was used. Flow around a specified initial profile is first calculated at the design point, the principle of elliptic continuation of the basic equation (fictitious gas concept) being used in the supersonic part of the flow to avoid the appearance of discontinuities. Using the sonic line so determined as the initial condition, the actual supersonic flow and

## 05 AIRCRAFT DESIGN, TESTING AND PERFORMANCE

its associated new supersonic contour is determined using a characteristic method. Calculations at the design point and off-design flight conditions show that requirements of free stream Mach number = 0.77, profile lift coefficient = 0.6, relative wing thickness = 0.11, and pitching moment or = -0.13 are met.

Author (ESA)

### **N85-31055# European Space Agency, Paris (France). DESIGN AND IMPLEMENTATION OF INPUT SIGNALS FOR IDENTIFICATION OF PILOT/AIRCRAFT MODELS**

R. KOEHLER Dec. 1984 44 p refs Transl. into ENGLISH of "Entwurf und Realisierung von Eingangssignalen zur Identifizierung eines Pilotenmodells" rept. DFVLR-FB-84-08 DFVLR, Brunswick, 1984 Original language report previously announced as N84-25709

(ESA-TT-880; DFVLR-FB-84-08) Avail: NTIS HC A03/MF A01; original German version available from DFVLR, Cologne DM 17

A flight test method to investigate flying qualities of combat aircraft in ground attack maneuvers is presented. Simulated attacks on dynamically switched ground based targets are carried out to assess flying qualities and to identify pilot/aircraft systems. The method was applied in pilot rating tests. The design of input signals and preparation of flight tests are described. Author (ESA)

**N85-31334#** - Joint Publications Research Service, Arlington, Va. **MBB DEMONSTRATES NEW RESEARCH AIRCRAFT ATTAS** *In its West Europe Rept.: Sci. and Technol. (JPRS-WST-85-020)* p 12-13 5 Jul. 1985 Transl. into ENGLISH from Frankfurter Allgem. Ztg. (Frankfurt am Main), 25 May 1985 p 8 Avail: NTIS HC A05/MF A01

The conversion of a VFW 614 into the research aircraft ATTAS (Advanced Technologies Testing Aircraft System) is discussed. The aircraft was stripped of cabin furnishings, control systems, landing flaps and power units. The cockpit was completely cleared of its instruments, and the wiring largely removed. The main aircraft structure was then newly outfitted. Electronic work stations and five modern computers were installed. The ATTAS can be given the flight characteristics of other aircraft. R.J.F.

## 06

### **AIRCRAFT INSTRUMENTATION**

Includes cockpit and cabin display devices; and flight instruments.

### **A85-40347# SPECIFIC DIFFERENCES IN FUTURE COCKPIT DESIGN DUE TO CIVIL AND MILITARY APPLICATIONS**

H. HELLMUTH and K. SCHYMANIETZ (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984, Paper. 10 p.

An evaluation and characterization is conducted for the divergences between civil and military helicopter cockpit designs anticipated for next-generation technology, encompassing control, navigation, communications, sensor, and display systems. Attention is given to the results obtained by a major civil and military helicopter manufacturer in the course of simulator-based studies of the range of component technologies whose maturity is anticipated in the near term. Attempts have been made in the simulation study to reduce the number of cockpit displays and integrate their symbologies, to relegate additional functions to direct vocal command control by the pilot, and to institute a fly-by-wire (or light) system which will not be mechanically constrained in its cockpit positions. O.C.

### **A85-40831#**

#### **AV-8B/GR MK5 ENGINE MONITORING SYSTEM**

G. A. COOPER, C. B. CARTER (Plessey Avionics, Havant, England), and A. HESS (U.S. Naval Air Systems Command, Washington, DC) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 8 p. (AIAA PAPER 85-1295)

The design features of the AV-8B/Harrier GR5 Engine Monitoring System (EMS) are described. The system was developed as a compact and powerful computing system for on-condition maintenance of the Pegasus gas turbine engine. The system consists of an Engine Monitoring Unit (EMU); a Quick Access data Recorder (QAR); and a Data Retrieval Unit (DRU) which receives signals transmitted from the EMU and makes them available to ground crews. Among the types of engine malfunction detected by the EMS are: hot starts; ac power surges; in flight relight; and vibration damage. A series of black and white photographs of the major electronics modules of the EMS is provided. I.H.

### **A85-40977#**

#### **MU-300 FLIGHT TEST DATA SYSTEM**

S. KAWASAWA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 363, 1984, p. 202-210. In Japanese. refs

The Mu-300 fan jet business aircraft achieved the first flight in August 1978, and obtained the FAA type certificate in November 1981. The paper describes the instrumentation system and data processing apparatus on the ground for the flight test of the MU-300. Flight tests were carried out with two aircraft: the first one was designated for testing take-off and landing, flight efficiency, and vibration, with test results recorded on a magnetic tape recorder; the second one carried out the testing efficiency of a power system by using a data logger. Instrumentation on the first test aircraft included a magnetic tape recorder for PCM signal and vibration data, onboard monitor, and telemetry transmitter. The second test aircraft included pressure transducers for measuring pressure, and thermocouple, thermister, and temperature resistance sensors for measuring the temperature. The PCM data were received on the ground data processing system consisting of a PCM bit synchronizer, PCM decommunicator, and tape formatter. The maintenance of the instrumentation system is discussed. S.H.

### **A85-40978#**

#### **STRESS MEASURING EQUIPMENTS FOR AIRCRAFT**

Y. IKEDA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 363, 1984, p. 210-217. In Japanese.

Stress measuring equipment for monitoring fatigue damage, and safety and reliability of aircraft are surveyed and illustrated with tables and diagrams. Instruments for monitoring structural safety of aircraft include counting accelerometers for MS 25448 and MS 2447-4, velocity-gravity-height (VGH) recording set for J/ASH-2, exceeding counter set for 574-102000-4, signal data recording set for AN/ASH-28, and load level comparator for TAC-17A. The counting accelerometer is used for monitoring hard-landing and recording load level during the flight training. The VGH recording set is designed for recording horizontal acceleration with pressure altitude, airspeed, and flying time on digital magnetic tape recorder. The structure and operating principle of the pressure sensor are given. S.H.

### **A85-40979#**

#### **AIRCRAFT FLIGHT RECORDER SYSTEM**

Y. TAKEMASA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 363, 1984, p. 217-223. In Japanese. refs

Aircraft flight recorder systems, including digital flight data recorder (DFDR), flight data recorder (FDR) employing magnetic tape and aircraft integrated data system (AIDS) are reviewed. Aircraft for domestic lines in Japan, such as the YS-11, is equipped with the FDR, and the Airbus A-300 is equipped with DFDR. The

flight recorder system consists of mandatory equipment including 3-axis accelerometer, control panel, digital flight data acquisition unit, and DFDR. The structure and functions of the DFDR are characterized. Input data signals and output data format are discussed. Specifications of aircraft flight recorders and environmental testing methods of flight recorders are included.

S.H.

**A85-40980#****ENVIRONMENTAL TESTING OF AVIONICS**

H. TAIRA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 363, 1984, p. 223-231. In Japanese. refs

Recent developments in environmental testing of avionics are described and illustrated with tables, block diagrams, and drawings, and testing procedures and sensors for avionics are discussed. Methods for measuring vibrations, temperature-height, reliability, and electromagnetic interference of avionics are presented. The reliability test is carried out according to U.S. MIL-STD-781 B. Electromagnetic interference tests include evaluations of emission and susceptibility.

S.H.

**A85-41017#****MULTIPLE SENSOR**

T. AIHARA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 369, 1984, p. 567-573. In Japanese. refs

The principle of multisensors for the digital flight control system is described. The role of the flight control sensors including position and command sensors for weight control, air data sensor, and momentum sensor are characterized. The skewed array method for constructing multisensors and inertial sensors are discussed. The identification and separation techniques of the failure of multisensor systems are described. Specifications of pressure sensors for air data, and inertial sensors for strapdown are included.

S.H.

**A85-41018#****MULTIPLEXED DATA BUS FOR AIRCRAFT AND ITS ROLE**

M. TAKIZAWA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 369, 1984, p. 573-583. In Japanese. refs

Development of time-division multiplexed data bus (MUX), its function, examples of MUX, and its applications to aircraft are described. System construction and characteristics of ARINC-429 DITS(429 MUX) and MIL-STD-1553 A/B MUX(1553 MUX) are discussed. The flight control system of the B-767 (employing 429 MUX), and the broadcast information transfer format of MIL-STD-1553A/B are analyzed. The 429 MUX is applied to the information transfer system of the STOL fanjet experimental aircraft, and a block diagram of the SCAS for the STOL is included. The 1553 MUX for the F-16 may be applied to data transfer systems for ships and spacecraft.

S.H.

**A85-41051#****A LANTIRN FOR SEEING IN THE DARK**

E. J. LERNER Aerospace America (ISSN 0740-722X), vol. 23, July 1985, p. 28, 29.

The Low Altitude Navigation and Targeting IR system for Night (LANTIRN) is comprised of a pair of targeting and navigation pods mounted externally on fighter and attack aircraft. An aimable IR imager with both wide and narrow fields of view for target tracking is carried by one pod, which also incorporates the laser designator that illuminates a target for laser-guided bombs and Maverick missiles. The navigation pod contains an IR imager that senses variations in the IR emissions of the terrain ahead and converts them into head-up display imagery. Attention is given to design features and performance capabilities of the LANTIRN electronic subsystems.

O.C.

**A85-41052#****GIANT SURVEILLANCE RADAR SQUEEZED INTO WING**

E. J. LERNER Aerospace America (ISSN 0740-722X), vol. 23, July 1985, p. 29, 30, 32.

A novel airborne early warning surveillance radar has been designed for E-2 class carrier-based aircraft which uses phased array principles to blend a very large antenna area conformally onto wing and fuselage surfaces. The antenna elements that permit this degree of conformance are end-fired devices, 'Yagis', with coupling that broadens the radiation pattern emitted by each element in the horizontal direction. The replacement of conventional radomes by such conformal systems will lead to greater aircraft loiter time through both structural weight reduction and aerodynamic efficiency improvements.

O.C.

**A85-41058#****PILOTS WARY OF TACTICAL INFORMATION SYSTEMS**

R. DEMEIS Aerospace America (ISSN 0740-722X), vol. 23, July 1985, p. 70-73.

The Joint Tactical Information Distribution System (JTIDS) employs frequency hopping techniques to furnish real time, secure, antijam digital data transfer and voice communications to remote terminals, automatically distinguishing between friend and foe and collecting navigation data relative to a master platform, such as an AWACS aircraft. In addition to the prospective air engagement advantages anticipated for JTIDS by the U.S. Air Force, the cost and complexity that have become associated with the system to date and the operational difficulties cited by pilots acquainted with test units of the JTIDS system are discussed.

O.C.

**A85-41397****USE OF PROGRAMMABLE CALCULATORS ONBOARD COMMERCIAL AIRCRAFT [EINSATZ VON PROGRAMMIERBAREN KLEINSTRECHNERN AN BORD VON VERKEHRSFLUGZEUGEN]**

M. CASPARI (Interflug Gesellschaft fuer Internationalen Flugverkehr mbH, Berlin, East Germany). Technisch-oekonomische Information der zivilen Luftfahrt (ISSN 0232-5012), vol. 21, no. 2, 1985, p. 52-54. In German.

The system of hand-held programmable calculators and specialized programs developed to permit the crews of Interflug aircraft to perform in-flight flight-plan-optimization computations is characterized. The hardware comprises a 12-kbyte operational-system calculator with 2.2-kbyte available memory, permanent memory, user-determined key assignment, and alphanumeric display; a rechargeable power supply; and a magnetic-card reader, while the software is contained on 43 magnetic cards (total capacity 7 kbyte) protected against intentional or unintentional alteration. The programs are specifically designed for each particular type of aircraft and cover loading and center-of-gravity determination, fueling, climb and horizontal-flight optimization, optimal descent, vertical navigation, landing, and flight-plan calculation (for the copilot). The organization of the system and the training programs are described.

T.K.

**A85-41532****AMONG THE WEEDS AT NIGHT - TRANSITION TO NIGHT NOE FLYING**

B. WANSTALL Interavia (ISSN 0020-5168), vol. 40, July 1985, p. 793-795.

An evaluation is made of the performance capabilities of helmet-mounted head-up electrooptical displays currently in use or under development, which are aimed at facilitating high performance, safe nap-of-the-earth flight operations at night for military helicopter pilots. Night vision goggles, which amplify nocturnal light levels, lack the capacity for direct superposition of essential flight information; this capability can be incorporated through the use of miniature CRTs, by which a combination of forward looking IR sensor imagery and flight data graphics can be projected directly into the helicopter pilot's eye.

O.C.



A85-42447#

**MICROCOMPUTER FOR AIRCRAFT GUN-SIGHT**

K. LI Northwest Polytechnical University, Journal, vol. 3, April 1985, p. 277-285. In Chinese, with abstract in English.

An aircraft guns-sight microcomputer system has been developed in order to replace one using discrete element semiconductor logic and enhance the defensive capability of Chinese aircraft. The new system reduces volume to about one-tenth, decreases the weight from 33 kg to several kg, greatly increases reliability, and makes operation and maintenance quite easy. The system consists of a microcomputer single board Z80, A/D-D/A board, and some electronic circuitry. Since the Z80 microprocessor is an eight-bit one without instructions for performing multiplication and division, several fast 16-bit subroutines must be designed to raise the operating speed. C.D.

A85-42893#

**THE METAMORPHOSIS OF THE MILITARY AIRCRAFT COCKPIT**

I. GLICKSTEIN (IBM Corp., Federal Systems Div., Oswego, NY) Aerospace America (ISSN 0740-722X), vol. 23, Aug. 1985, p. 48-50, 52.

Advances in AI and automation technologies are enabling the development of the 'rational cockpit', which will adjust the pilot's role to one of a flight manager. Already, in the HH-60A Night Hawk combat search and rescue helicopter, the crew serves as the interface between the helicopter and the avionics. The HH-60A CRTs display present combinations of sensor video, symbology and tabular data on pilot request. Conformal symbology and thermal imagery are generated in helmet mounted displays. The avionics system has reduced the HH-60A crew to two from four. Research continues on a 'pilot's associate' expert system, which will handle routine tasks and those a human pilot cannot do, particularly aircraft systems status examinations. Combat maneuvers may also be programmed into the associate. The capabilities may be extended to present an artificial visual panorama in degraded visibility conditions and controls responsive to voice, touch, and eye and head positions. M.S.K.

A85-42896#

**AVIONICS UNRELIABILITY TURNS FIGHTERS INTO SHOP QUEENS**

E. J. LERNER Aerospace America (ISSN 0740-722X), vol. 23, Aug. 1985, p. 68-70.

An Aerospace America study has identified avionics maintenance as a major contributor to problems with F-15, -16, -4, -111 and A-7 aircraft combat. Shop hours in some instances average at least as much as flight hours. The data also indicate that aircraft with simpler designs are more reliable. The performance, and hence complexity, of a system seem to define the MTBF. The problems are best eliminated in the design stage, and new problems in the redesign stage. It is noted that the financial attractiveness of being the sole-source supplier of spare parts for defense department line aircraft is a de facto disincentive to manufacturers to upgrade reliability. M.S.K.

N85-29953 Department of the Navy, Washington, D. C.

**GEOMAGNETIC VELOCIMETER Patent**

D. KRASNJANSKI, inventor (to Navy) 2 Apr. 1985 '6 p

(AD-D011672; US-PATENT-4,509,131;

US-PATENT-APPL-SN-383429; US-PATENT-CLASS-364-565)

Avail: US Patent and Trademark Office CSCL 01D

A velocity measuring system utilizes a pair of magnetic sensors each mounted in a displaced location with respect to the other on an aircraft whereby such sensors passing over the same stationary base location at different times provide geomagnetic field signals to a correlator circuit for producing a value for the ground speed of the aircraft. GRA

07

**AIRCRAFT PROPULSION AND POWER**

Includes prime propulsion systems and systems components, e.g., gas turbine engines and compressors; and on-board auxiliary power plants for aircraft.

A85-40070

**ARE PROPELLERS COMING BACK - AND WHEN?**

B. SWEETMAN, N. COOK, and P. CONDOM Interavia (ISSN 0020-5168), vol. 40, June 1985, p. 615-617, 619, 620.

The design features and development pace prospects for several major geared propfan and gearless 'unducted fan' (UDF) development initiatives are discussed with a view to projected efficiency gains and the long term economic viability of such radical research and development programs. Attention is given to the difficulties posed by gearbox weight with increasing engine size, the advantages of counter-rotating rotors, and the weight-minimization consequences of UDF fan drive configurations. Plans by airframe manufacturers to tailor future transport aircraft designs for propulsion systems of this novel type are surveyed. O.C.

A85-40330#

**'THE TEST STAND FLIES WITH THE AIRCRAFT' - ENGINE CONDITION MONITORING IN THE CASE OF THE AIRBUS A 310 OF THE LUFTHANSA ['DER PRUEFSTAND FLIEGT MIT' - TRIEBWERKSZUSTANDSUEBERWACHUNG BEIM AIRBUS A 310 DER LUFTHANSA]**

G. DIENGER (Deutsche Lufthansa AG, Hamburg, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 17 p. In German. refs (DGLR PAPER 84-114)

With the introduction of the A 310, the West German airline 'Lufthansa' has adopted a new approach with respect to its engine condition monitoring and engine maintenance operations. The new concepts were adopted with the objective to reduce the total operational costs for the engine, which consists of fuel costs and maintenance costs. An additional objective is related to the desire to avoid costly operational disturbances. According to the new approach, engine condition monitoring devices are first used to study the new engine, which is provided by an American engine manufacturer, before the installation in an aircraft. The information provided by the employed instrumentation indicates, in addition to the occurrence of a disturbance, also the type of the disturbance and the involved engine module. After its installation with the engine in the aircraft, the engine condition monitoring equipment continues its service. Plans for maintenance and repair work are based on the provided data, as illustrated with the aid of examples. G.R.

A85-40538

**THE HISTORY AND FUTURE OF THE CENTRIFUGAL COMPRESSOR IN AVIATION GAS TURBINES**

D. P. KENNY (Pratt and Whitney Canada, Inc., Longueuil, Canada) Society of Automotive Engineers, Giff Garrett Turbomachinery Award Lecture, 1st, Long Beach, CA, Oct. 16, 1984. 20 p. refs

(SAE PAPER 841635; SAE SP-602)

The development of turbomachinery into the modern centrifugal compressor from Greek classic times to the demonstration of the first aviation gas turbines is traced. This is followed by a description of the evolution of the current high performance centrifugal compressors found in today's engines and some of the leading research demonstrations of the past decade. Recent developments in computer power indicate a massive increase in numerical analysis capability to full three-dimensional viscous solutions. The application of this to the future evolution of centrifugal compressor capability is discussed, with projections for improvements in performance over the next decade. The problems which limit the

performance of centrifugal compressors are noted and arguments are presented regarding their solutions. Author

**A85-40830\*#** National Aeronautics and Space Administration. Flight Research Center, Edwards, Calif.

**FAULT DETECTION AND ACCOMMODATION TESTING ON AN F100 ENGINE IN AN F-15 AIRPLANE**

L. P. MYERS, J. L. BAER-RIEDHART (NASA, Flight Research Center, Edwards, CA), and M. D. MAXWELL (United Technologies Corp., Pratt and Whitney Aircraft Group, West Palm Beach, FL) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 14 p. (AIAA PAPER 85-1294)

The fault detection and accommodation (FDA) methods that can be used for digital engine control systems are presently subjected to a flight test program in the case of the F-15 fighter's F100 engine electronic controls, inducing selected faults and then evaluating the resulting digital engine control responses. In general, flight test results were found to compare well with both ground tests and predictions. It is noted that the inducement of dual-pressure failures was not feasible, since FDA logic was not designed to accommodate them. O.C.

**A85-40836#**

**APPLICATION OF FREQUENCY DOMAIN AND TIME DOMAIN ANALYSIS TOOLS TO THE ANALYSIS OF NONRECOVERABLE STALL**

S. M. ROCK (Systems Control Technology, Inc., Palo Alto, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 7 p. (Contract F33615-80-C-2028) (AIAA PAPER 85-1350)

One characteristic of many modern aircraft turbine engines is to stall or surge during operation at particular flow and speed conditions. Of critical importance is that recovery occur quickly without the necessity for pilot action. Unfortunately, some modern turbofans may reach a situation termed nonrecoverable stall, which has led to the loss of the engine and aircraft in some cases. Both component redesign and modified control logic provide possible solutions for avoiding nonrecoverable stall. However, the utilization of these possibilities requires a thorough understanding of the engine's behavior in the poststall environment. A series of test and evaluation programs have been sponsored by the Air Force and NASA with the objective to obtain such an understanding. The present paper is concerned with one part of these efforts, taking into account studies in which an American company has demonstrated the utility of both frequency domain and time domain analysis techniques for identifying and explaining phenomena characteristic of nonrecoverable stall. G.R.

**A85-40837#**

**IDENTIFICATION OF QUASI-STEADY IN-STALL COMPRESSOR MAPS FROM TRANSIENT DATA**

R. P. ANEX, JR. and S. M. ROCK (Systems Control Technology, Inc., Palo Alto, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 11 p. refs (AIAA PAPER 85-1351)

A program, funded by the NASA Lewis Research Center and which applies methods of integrated system identification and test planning in its investigation of the post-stall operation of gas turbine engines, is described. Techniques which allow the definition of test procedures required for identification, the identification of compressor model parameters and model structures, and the evaluation of the identifiability and sensitivity of identified parameters, are developed and demonstrated. Consideration is given to the high-speed research compressor rig which represents the data and model used in the program and to the SCT identification code, SCIDNT, which forms estimates of model parameters by minimizing the error between the model outputs and the measured rig data. M.D.

**A85-40840#**

**TURBOFAN-ENGINE NONRECOVERABLE STALL COMPUTER-SIMULATION DEVELOPMENT AND VALIDATION**

W. M. HOSNY, S. J. BITTER, and W. G. STEENKEN (General Electric Co., Cincinnati, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 13 p.

(Contract F33615-79-C-2060)

(AIAA PAPER 85-1432)

A digital computer model with nonrecoverable stall capability was developed to simulate the F101X augmented turbofan engine. The model is based on the standard steady-state and transient cycle deck codes. The compressor and the fan-hub and fan-tip maps were extended to include in-stall and reverse flow representations while the combustor characteristics were extended to include both rich and lean performance characteristics and flammability limits. The dynamic response of the model was enhanced by using volume dynamic routines to represent engine ducts and volumes. The three governing unsteady one-dimensional conservation equations were applied to represent the dynamics in the engine ducts and the four governing unsteady two-dimensional conservation equations were applied to represent the fan duct volumes. These modifications provided the model with the capability to reproduce the aerophysics associated with surge, rotating stall, and nonrecoverable stall simulations. Mainburner-fuel-step, fuel cutoff and relight, and afterburner-fuel-pulse transient simulations were conducted and the sequences of events leading to nonrecoverable stall were investigated. Comparisons with test data clearly substantiate the fidelity of the model in reproducing the events leading to recoverable and nonrecoverable stalls. Author

**A85-40841\*#** General Electric Co., Cincinnati, Ohio.

**STALL RECOVERY CONTROL STRATEGY METHODOLOGY AND RESULTS**

W. R. HOPF and W. G. STEENKEN (General Electric Co., Cincinnati, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 14 p. refs (Contract NAS3-23540)

(AIAA PAPER 85-1433)

The nonrecoverable stall condition in high performance turbofan engines is characterized by thrust loss, rising turbine temperatures, high pressure compressor rotating stall, and loss of engine control. Stall recovery control is presently investigated by means of an engine system computer model capable of either surge or rotating stall postinstability operation. Several techniques are examined which can yield rapid recovery from stall; a composite strategy which involves reduction of engine speed to idle while simultaneously opening the 10th- and 14th-stage compressor bleed ports allowed recovery to speeds slightly higher than idle while combustor fuel flow continued. O.C.

**A85-40843#**

**DEVELOPING A DERIVATIVE ENGINE**

W. E. CRESLEIN (United Technologies Corp., Pratt and Whitney Aircraft Group, West Palm Beach, FL) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 7 p. refs

(AIAA PAPER 85-1462)

The development of derivatives from existing and developmentally mature high performance engines, such as the F100 fighter engine presently considered, lowers the technical risks and costs that would be incurred through the production of an entirely new design. This is especially true in the case of the expansion of economies of scale for components used in common by parent and derivative engines. Attention is presently given to the derivation of the PW1120 low bypass turbofan from the F100, from initial market analyses through engine cycle definition, tests, and flight certification. O.C.

## 07 AIRCRAFT PROPULSION AND POWER

**A85-40912#**

### **THE 'NEW LOOK' RAMJET**

J.-C. SALVINIEN. *Revue Aerospatiale* (ISSN 0065-3780), April 1985, p. 28, 29. Translation.

New French military requirements for a nuclear tipped missile have caused the resuscitation and development of an operational ramjet. Using kerosene fuel and a solid fuel booster, an aircraft launch is effected with air ducts closed. Once supersonic speeds are reached the ducts open and the ramjet is ignited, the booster nozzle being jettisoned. The engine is currently undergoing ground-test firings through use of a supersonic airflow supply. The engine will serve on air-to-ground missiles. S.H.

**A85-41013#**

### **A STUDY OF RAMJET ENGINE. II - ALTITUDE SPECIFIC RANGE AT THE CEILING**

K. FUNAKI. *Japan Society for Aeronautical and Space Sciences, Journal* (ISSN 0021-4663), vol. 32, no. 368, 1984, p. 525-532. In Japanese, with abstract in English.

The flight range of a vehicle propelled by a ramjet engine from the viewpoint of the vehicle-engine design trends is studied. Of interest is to know how far it can fly for a given amount of fuel, which depends on the selection of fundamental design parameters and the component performance characteristics, as well. Effects, such as Mach number, altitude, lifting force, drag force, vehicle frontal projected areas, vehicle weight, pressure recovery at the inlet and energy density of fuel were analyzed. It was found that the flight altitude is the predominant factor in determining the flight range with the higher altitude resulting in the longer flight. However, there exists a limit in the flight range, called the aerodynamic ceiling altitude, at which the vehicle lifting force must at least support the vehicle weight, consequently determining the longest possible flight range. The aerodynamic ceiling altitude was found to increase almost linearly with respect to the Mach number, up to the design value but remains nearly constant above it. The aerodynamic ceiling altitude, therefore, limits the flight range at higher Mach numbers than the design. Author

**A85-41025#**

### **DEVELOPMENT TREND ON AIRCRAFT GAS TURBINE ENGINE**

K. MURASHIMA. *Japan Society for Aeronautical and Space Sciences, Journal* (ISSN 0021-4663), vol. 32, no. 371, 1984, p. 668-677. In Japanese. refs

Type and requirements of gas turbine engines, cycle parameters, and testing items for engine type certification are analyzed. Gas turbines studied include high efficiency bypass turbofans, variable cycle turbofans, propfans, turbofans with low efficiency bypass afterburners, turboprops, and disposable small turbojets. The cycle parameters, such as maximum propulsion force, fuel consumption rate, total pressure ratio, inlet temperature, bypass ratio, and propulsion force/weight ratio are characterized. The FJR 710 turbofan engine (propulsion force about 5t) is developed for the STOL experimental aircraft in Japan. The development of the small engine XJ4 for rockets is discussed. S.H.

**A85-41027#**

### **COMBUSTORS AND THEIR EMISSION CONTROL TECHNIQUE**

T. TAMARU. *Japan Society for Aeronautical and Space Sciences, Journal* (ISSN 0021-4663), vol. 32, no. 371, 1984, p. 683-688. In Japanese. refs

Gas turbine emission control is described, stressing the FJR 710 and JR lift engines. The combustor for the FJR 710, employing a spray cone and a vaporizing tube, is analyzed. Methods for reducing emissions of hydrocarbons, CO, and nitric oxides, and emission exhaust fumes are described. Gas composition from the FJR 710 emission meets the EPA requirement. S.H.

**A85-41028#**

### **TURBINE COMPONENT TECHNOLOGY**

K. TAKAHARA. *Japan Society for Aeronautical and Space Sciences, Journal* (ISSN 0021-4663), vol. 32, no. 371, 1984, p. 688-695. In Japanese. refs

Turbine component technology is described, with emphasis on aerodynamics and cooling efficiency. The operating conditions and structures of high and low pressure turbines are analyzed, noting that minimizing the tip clearance to reduce pressure loss improves the heat insulation efficiency. Various cooling methods of turbine blades are compared, and relationships between turbine materials and stress of turbine components are described. S.H.

**A85-41029#**

### **STRUCTURAL ANALYSIS OF AIRCRAFT GAS TURBINE ENGINES**

H. MAKITA. *Japan Society for Aeronautical and Space Sciences, Journal* (ISSN 0021-4663), vol. 32, no. 371, 1984, p. 695-700. In Japanese. refs

Current status in structural analysis of gas turbine engines for aircraft and future prospects are described. Requirements for airworthiness are discussed. Methods include FEM and boundary element method, CAD system, Nastran analysis, MIL-E-5007D analysis, and vibration analysis of rotors. Progress in computational mechanics by improving FEM and BEM methods, and CAD systems are expected. S.H.

**A85-41030#**

### **NEW FUNCTIONAL REQUIREMENT TO AERO-ENGINE CONTROL SYSTEM**

S. SUGIYAMA. *Japan Society for Aeronautical and Space Sciences, Journal* (ISSN 0021-4663), vol. 32, no. 371, 1984, p. 701-706. In Japanese. refs

Aircraft engine control is reviewed with respect to improvements of performance characteristics of turbojet engines and efficiency in operating airframe/engine system. The electronic supervisory control system, thrust management system, integration of flight and propulsion control system, thrust management system, integration of flight and propulsion control system, FADEC/F-14 system integration for improving operational safety, and the maintenance monitoring system are described. S.H.

**A85-41031#**

### **NOISE CONTROL TECHNOLOGY FOR GAS TURBINE ENGINES**

S. KAJI. *Japan Society for Aeronautical and Space Sciences, Journal* (ISSN 0021-4663), vol. 32, no. 371, 1984, p. 707-714. In Japanese. refs

Recent developments in noise control of gas turbine engines are described, stressing work on noise of high bypass ratio fan and jet engines. The rotational noise of fans can be reduced by employing single stage fans and raked stator blades, elimination of front stator blades, and an increase in the clearance between rotor and stator blades. Methods for reducing noise of subsonic jet engines, and variable cycle engines for reducing noise of supersonics are analyzed. S.H.

**A85-41034#**

### **ON THE PROPULSION SYSTEM OF THE QUIET STOL RESEARCH AIRCRAFT**

M. MORITA, M. SASAKI, K. TAKASAWA, and T. TORISAKI. *Japan Society for Aeronautical and Space Sciences, Journal* (ISSN 0021-4663), vol. 32, no. 371, 1984, p. 731-739. In Japanese. refs

Design and construction of the propulsion system of the quiet STOL aircraft, and its characteristics are described. Presently the STOL is under final construction stage. The FJR 710/600S engine is a modified version of the high bypass ratio turbofan engine FJR 710/600. The upper surface blowing (USB) powered high lift system is applied to the propulsion system of the STOL, and its specifications are illustrated. Testing methods for powered high lift device and wind tunnel, engine matching, and ground system are described. S.H.

A85-41035#

**V2500 TURBOFAN ENGINE**

M. ITO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 371, 1984, p. 739-744. In Japanese.

The development of the V2500 engine started in 1984 under the joint efforts of the U.S., England, Japan, West Germany, and Italy. Structural dimensions and characteristics of the engine are analyzed in detail. Various modules including the high pressure compressor, turbines, combustor, and gear box are characterized. A development schedule is provided. S.H.

A85-41420#

**BENEFITS OF BLADE SWEEP FOR ADVANCED TURBOPROPS**

F. B. METZGER and C. ROHRBACH (United Technologies Corp., Hamilton Standard Div., Windsor Locks, CT) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 12 p. refs (AIAA PAPER 85-1260)

Blade sweep is one of the features incorporated in Advanced Turboprop (Prop-Fan) designs. Sweep is incorporated to enhance efficiency and reduce noise. This paper discusses the theoretical basis for performance enhancement and noise reduction and discusses the experimental evidence demonstrating the value of this feature in current Prop-Fan designs. Emphasis is on single rotation Prop-Fans but benefits to counter rotation Prop-Fan designs are discussed briefly. Author

A85-41776

**1983 TOKYO INTERNATIONAL GAS TURBINE CONGRESS, TOKYO, JAPAN, OCTOBER 23-29, 1983, PROCEEDINGS, VOLUMES 1, 2 & 3**

Congress sponsored by the Gas Turbine Society of Japan. Tokyo, Gas Turbine Society of Japan, 1984. Vol. 1, 421 p.; vol. 2, 404 p.; vol. 3, 411 p. For individual items see A85-41777 to A85-41855.

The present gas turbine technology conference ranges over such major topics as external surface heat transfer, unsteady heat transfer, internal surface heat transfer, heat exchangers, film cooling methods, the development status of combustors, the use of hydrogen as a gas turbine fuel, combustion-related research methods, gas turbine emissions, heavy oil combustion, and gas turbine cycles. Also discussed are turbomachine aerodynamics, radial flows, computational aerodynamics, steady and unsteady aerodynamics, turbocharger design, vehicular gas turbines, control and monitoring systems, gas turbine materials and manufacturing methods, combined cycle designs and their performance, aircraft gas turbines, and vibrational and dynamic characteristics of turbomachinery. O.C.

A85-41777

**A SURVEY ON GAS TURBINE TECHNOLOGY AND RESEARCH WORK IN JAPAN**

H. TANAKA (Tokyo, University, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 1. Tokyo, Gas Turbine Society of Japan, 1984, p. S-1 to S-17. refs

In recent years, the gas turbine has assumed an increasing importance in the necessity of saving energy since the oil crisis in 1973 and the gas turbine technology has made marked progress in Japan based on the fruitful results of research and development of gas turbine components. It is the purpose of this paper to survey the research work, technology and development of gas turbine in Japan advanced in these several years after the Tokyo Joint Gas Turbine Congress held in Tokyo in 1977; fundamental researches on aerodynamics of axial flows, radial flows, boundary layers, unsteady flows and acoustic noise, on combustors, pollutant emissions, combustion of low calorific fuels and alternative fuels, on heat transfer of vane and blade cooling and disk cooling, and on materials of superalloys, coating and ceramics, and development of jet engines, industrial gas turbines, vehicular gas turbines and turbochargers. Author

A85-41778\* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

**THE TREND OF FUTURE GAS TURBINE TECHNOLOGY**

M. J. HARTMANN (NASA, Lewis Research Center, Cleveland, OH) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 1. Tokyo, Gas Turbine Society of Japan, 1984, p. S-19 to S-25.

Future gas turbine technology will be based on contributions to the technology base being made today. At the NASA Lewis Research Center in Cleveland, OH, research is being conducted on turbomachinery system components and in a number of associated disciplines to advance the technology of aviation turbofan and turbojet engines. Areas of research include compressors, turbines, internal flow analysis, combustion, fuels, materials, structures, bearings, seals, lubrication, dynamics and controls, and instrumentation. A review of the research directions being taken in these areas and the steady advances being made provides a reasonable glimpse at gas turbine technology of the future. Author

A85-41783

**UNSTEADY TEMPERATURE ANALYSIS OF AIR-COOLED TURBINE VANES**

T. YOSHIDA, T. KUMAGAI, and F. MINURA (National Aerospace Laboratory, Chofu, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 1. Tokyo, Gas Turbine Society of Japan, 1984, p. 51-58. Research supported by the Agency of Industrial Science and Technology. refs

Unsteady hot cascade tests were performed for four cases with two kinds of full scale turbine nozzle vane models, FJR type and NAL type, with and without thermal barrier coating (TBC), respectively. Time constants of vane metal temperatures during transient conditions by igniting or cutting off fuel were studied; in addition, two dimensional transient temperature distributions on suction surfaces were measured with an infrared thermal camera. The experimental ranges are as follows:  $Re = 2 \times 10$  to the 5th to  $2 \times 10$  to the 6th, total pressure at cascade inlet ranging from 0.3 to 0.9 MPa, and total temperature at cascade inlet ranging from 340 to 1080 K. Spatial variations of time constants were fairly uniform except for the NAL vane with TBC. TBC generally makes a time constant slow and it exerts influences even over the range where it is not applied. The characteristics of time constant and heat transfer were extended to the range of  $Re = 2 \times 10$  to the 6th. Author

A85-41785

**IMPINGEMENT COOLING OF GAS TURBINE COMPONENTS**

G. E. ANDREWS and C. I. HUSSAIN (Leeds University, England) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 1. Tokyo, Gas Turbine Society of Japan, 1984, p. 67-74. SERC-supported research. refs

Impingement cooling heat transfer data were obtained for test geometries relevant to full coverage gas turbine combustion chamber wall cooling with the full flame tube pressure loss across the impingement plate. An impingement hole pitch to diameter ratio ( $X/D$ ) of between 10 and 13 is appropriate for this application and two test geometries within this range were studied. The impingement gap to hole diameter ratio ( $Z/D$ ) was the main parameter studied together with the hole Reynolds number. A significant influence of  $Z/D$  on the heat transfer was found and a general correlation equation derived. Evidence of enhanced impingement heat transfer for  $Z/D$  less than unity was found.

Author

## 07 AIRCRAFT PROPULSION AND POWER

**A85-41786**

### **IMPINGEMENT COOLING OF TURBINE AIRFOILS BY MULTIPLE TWO-DIMENSIONAL JETS**

L. S. HAN (Ohio State University, Columbus), N. KAYANSAYAN (Ege University, Izmir, Turkey), and C. W. DANTZER (General Motors Corp., Indianapolis, IN) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 1. Tokyo, Gas Turbine Society of Japan, 1984, p. 75-82. refs

The localized high heat transfer rates obtained through impingement internal cooling of gas turbine blades decay rapidly as the jets spread from their center of impact; an attempt is presently made to alleviate this and related drawbacks through the use of spanwise, two-dimensional jet impingement, varying jet spacing, height, and Reynolds number within typical turbine blade cooling system values. One set of experiments was run with equal flow for all jets, while the other employed increased flow rates for the jets on either side of the airfoil line of symmetry. Correlation are presented for the average heat transfer coefficients over the region facing the jets. O.C.

**A85-41788**

### **EXPERIMENTAL STUDY OF TEMPERATURE EFFECT ON TURBINE VANE COOLING PERFORMANCE WITH MULTI-ROW EJECTION**

K. SAKATA and T. KUMAGAI (National Aerospace Laboratory, Tokyo, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 1. Tokyo, Gas Turbine Society of Japan, 1984, p. 127-134. refs

Air-cooled turbine vanes adopting multi-row film cooling were designed and two dimensional high temperature cascade tests were carried out. Two types of the test models were manufactured to clarify gas temperature effects on the cooling performance. The test results show that the gas temperature strongly affects on the cooling effectiveness by changing the gas properties and coolant flow distribution to the ejection holes. These effects can be explained by the theoretical consideration and numerical prediction with the proposed analytical equations. Author

**A85-41789**

### **A DESIGN TECHNIQUE FOR ALL SORTS OF GAS TURBINE COMBUSTORS**

K. SUZUKI (Agency of Industrial Science and Technology, Mechanical Engineering Laboratory, Tsukuba, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 1. Tokyo, Gas Turbine Society of Japan, 1984, p. 143-149.

A design technique for general type of gas turbine combustor has been developed based on experimental results. The inside of the combustor liner is divided tentatively into three zones, namely, primary combustion zone, secondary combustion zone and dilution zone. Then the basic experimental data concerning each zone are applied to determine the required dimensions. This technique was utilized the design of several engine combustors and these combustors showed sufficient performance for the requirements. After that a computer program for calculation of the combustor main dimensions has been developed based on the technique. Combustion tests are, however, inevitable to design in detail and to improve the performances. Author

**A85-41790**

### **COMBUSTOR DEVELOPMENT FOR FJR710/600 ENGINE**

T. TAMARU, A. ISHII, T. SAITO, S. HORIUCHI (National Aerospace Laboratory, Chofu, Japan), and K. SUZUKI (Agency of Industrial Science and Technology, Mechanical Engineering Laboratory, Sakura, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 1. Tokyo, Gas Turbine Society of Japan, 1984, p. 151-157. Research sponsored by the Ministry of International Trade and Industry. refs

The FJR710 is the first turbofan engine ever developed in Japan. Some subjects on the research and development of the combustion chamber are described in this paper. The combustion

chamber is a conventional type; providing pressure atomizing fuel nozzles and air swirlers. To improve the liner life and the performance, the liner cowling shape was determined taking into account of the radial velocity profile of the incoming flow and the dumped diffuser configuration to distribute the flow most properly around the liner. Retarding the cracking point beyond the idling condition, i.e., no main fuel supply at the idling condition, reduced the unburned fuel pollutant emission significantly. It reduced the THC and CO emission levels to 1/10 and 1/2, respectively, at the idling condition. Smoke reduction was achieved by adopting new air swirlers. Author

**A85-41794**

### **RECENT ADVANCES IN VAPORISER FUEL INJECTION TECHNOLOGY**

A. SOTHERAN (Rolls-Royce, Ltd., Bristol, England) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 1. Tokyo, Gas Turbine Society of Japan, 1984, p. 181-188. refs

In recent years a number of research and full scale demonstrator programmes have been undertaken to extend the applicability of the Rolls-Royce vaporizer fuel injection system to the high pressure ratio, advanced-cycle engines now being proposed for both military and civil applications. The broad objective is to ensure the durability of the vaporizer and combustor at the required high levels of duty, whilst retaining competitive ignition, emissions control, outlet temperature pattern factor and other performance characteristics. The program has included investigations of the two-phase flow through and from the vaporizer, heat transfer rates to the body of the vaporizer and to the fuel and the effectiveness and durability of candidate vaporizer geometries and materials, including their thermal cycle properties. Author

**A85-41806**

### **CORE COMPRESSOR DEVELOPMENTS FOR LARGE CIVIL JET ENGINES**

C. FREEMAN and R. E. DAWSON (Rolls-Royce, Ltd., Derby, England) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 361-368. refs

An evaluation is made of the development status, and projections are made for the development prospects, of core compressor technology and its performance levels in the case of large civil aviation gas turbine power-plants, with attention to improvements over the last 30 years in mass flow, efficiency, pressure ratio/stage, and surge margin. A survey is made of the most promising experimental results currently being obtained by test stand-operated compressors and dedicated research compressors. Also noted are boundary layer calculation results and three-dimensional viscous calculations that illuminate prospects for efficiency improvement. Long term improvements are anticipated through the use of better blade clearance control, lower hub/tip ratios, improved blade pressure distribution, and stiffer blade materials for thinner blades. O.C.

**A85-41807**

### **DESIGN AND PERFORMANCE COMPARISON OF THREE HIGH-SPEED FANS**

S. FUJII, H. NISHIWAKI, and M. GOMI (National Aerospace Laboratory, Chofu, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 369-376. refs

A long-term research program for the years 1967-1981 was carried out to design and test high-speed, high-pressure-ratio scale model fans with booster stages. This paper summarizes the aerodynamic aspects of the program, with special reference to the design concepts and experimental results. A streamline curvature technique was used. The fan research was directed towards increasing the inlet tip relative velocity up to Mach 1.4. Multiple- and double-circular-arc blade profiles were employed. The flow separation due to the presence of swept blade rows is also discussed. Author

A85-41808

**AN EXPERIMENTAL INVESTIGATION OF PRESSURE LOSSES IN COOLING AIR SUPPLY SYSTEM FOR GAS TURBINE ROTOR**

N. KOBAYASHI, M. MATSUMOTO, and M. SHIZUYA (Hitachi, Ltd., Mechanical Engineering Research Laboratory, Hitachi, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 377-380.

Pressure distributions through the cooling air passages of high temperature gas turbine blades are presently measured, and the pressure losses generated within the rotor are analyzed taking rotational effects into account. The results obtained indicate that the pressure distributions within the rotor are significantly affected by the behavior of swirling flow, thereby resulting in large pressure losses. In addition, a linear dependency is noted between the logarithm of total pressure loss coefficient and the logarithm of the velocity ratio. O.C.

A85-41811

**ENVIRONMENTAL PROBLEMS IN TURBOMACHINERY**

W. TABAKOFF and A. HAMED (Cincinnati, University, OH) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 399-406. refs (Contract DAAG29-82-K-0029)

This paper presents the methods and results of several theoretical and experimental investigations concerning the effect of the presence of solid particles on the performance of turbomachinery. First, the results from a theoretical model are presented for predicting the changes in the pressure distributions over turbine cascade blades followed by the measured change in a turbine performance due to the presence of solid particles in a compressible flow. Secondly, the findings of an experimental investigation of the blade erosion conducted in a gas-particle compressor cascade tunnel are presented showing the change in the pressure coefficient with erosion. Third, the investigations of the dynamics of solid particles in turbomachines and their findings in regard to the locations as well as the velocities, direction and number of particles impacting the engine component surfaces are summarized. Fourth and fifth, a summary of the state of the art for the erosion behavior of materials in multiphase flows, and blade erosion prediction in turbomachinery. Author

A85-41812

**MATHEMATICAL MODELLING OF PERFORMANCE CHARACTERISTICS AND OPTIMIZATION OF TURBOMACHINE STAGES**

K. P. SELEZNEV and I. U. B. GALERKIN (Leningradskii Politekhnikeskii Institut, Leningrad, USSR) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 407-414.

A mathematical model of performance characteristics of stages is a system of algebraic equations meant to calculate all the components of losses and the Euler's head. Losses and Euler's head are functions of an inviscid flow velocity distribution parameters and similarity criteria. The unknown correlation coefficients should be found from stage performance tests by means of mathematical statistics. A number of models for different application have been developed for the stages of industrial centrifugal compressors. The coefficients in the equations are found from test results of about 250 stages. A model for calculating the performance over the entire range of flows is incorporated into the complex of programs for automatic designing of turbomachine stages. The optimization of flow passages is achieved by comparing a number of versions. The good practical results open up avenues for the application of the method to stages of other types of turbomachines. Author

A85-41829

**MEASUREMENT OF UNSTEADY PRESSURE DISTRIBUTION ON OSCILLATING AIRFOILS IN A TURBINE ANNULAR CASCADE**

H. KOBAYASHI (National Aerospace Laboratory, Chofu, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 539-546. Research supported by the Ministry of International Trade and Industry. refs

The annular test facility was designed and constructed in NAL to acquire fundamental aeroelastic cascade data, where whole 16 blades in annular cascade can be harmonically oscillated in torsional mode at frequencies up to 500 Hz with constant amplitude and interblade phase angle, by mechanical oscillatory system. In this facility, Freon gas is used as a working fluid to simulate actual high reduced frequency in cascade flutter. This paper describes the characteristics of this test facility and the transonic flow fluid unsteady turbine cascade experiment, wherein the chordwise distributions of unsteady pressure magnitude and its phase lag as referenced to the airfoil motion were measured at reduced frequency up to 0.940 based on chord and cascade outlet flow Mach number up to 1.32. Experimental data indicate the significance of the reduced frequency and cascade outlet Mach number on unsteady aerodynamic force acting on oscillating transonic flow turbine cascade. Author

A85-41836

**ANALYSES OF CASCADE FLUTTER AS A MULTI-EIGENVALUE PROBLEM (ON CASCADE COMPOSED OF TWO GROUPS OF BLADES HAVING DIFFERENT NATURAL FREQUENCIES)**

H. TANAKA, Y. HANAMURA, and I. FUJIMOTO (Tokyo, University, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 651-658. refs

Analyses of nonuniform cascade flutter are performed not from the viewpoint of mistuning problem but of flutter suppression in active sense. A computational method is developed as a multi-eigenvalue problem to analyze the characteristics of nonuniform cascade composed of blades with arbitrary natural frequencies. Numerical results are obtained for the several cases of blade arrangements mainly in compressor cascade which contains two kinds of blades having different natural frequencies, and some fundamental characteristics of flutter suppression effects, flutter modes, and mode selection are made clear. Author

A85-41839

**DEVELOPMENT OF LOW COST DIGITAL CONTROL SYSTEM FOR SMALL GAS TURBINE ENGINE**

K. KISHIMOTO, M. SAKURA (Mitsubishi Heavy Industries, Ltd., Nagoya, Japan), and K. SHIMAZAKI (Chuo Engineering Co., Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 3. Tokyo, Gas Turbine Society of Japan, 1984, p. 717-722.

A development status and performance assessment is made for a low cost digital control system that can be applied to a range of different gas turbine engines of output lower than 1000 hp. The low costs achieved in this system's manufacture and field maintenance are predicated on the independent development of microprocessor-based universal digital control units and stepping motor technologies. The system consists of a processing unit, a stepping motor valve, sensing devices, and several on/off units. The system is shown to successfully function as a fuel control unit for both aircraft jet engine and low power gas turbine applications. O.C.



## 07 AIRCRAFT PROPULSION AND POWER

A85-41840

### APPLICATION OF AIRCRAFT INTEGRATED DATA SYSTEM ON JET ENGINE MODULE PERFORMANCE MONITORING AND TURBINE BLADE LIFE ACCOUNTING

K. WATANABE, M. NAKAI, and O. SASAHARA (Japan Air Lines, Engineering Dept., Tokyo, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 3. Tokyo, Gas Turbine Society of Japan, 1984, p. 723-727.

An evaluation is made of the experiences of a major airline with the Aircraft Integrated Data System (AIDS) of its 747s and DC-10s, with emphasis on the monitoring of engine gas generator deterioration and the effectiveness of estimates of turbine blade and vane service lives. These are the responsibilities of the Engine Condition Monitoring and Module Performance Analysis elements of AIDS, which relay their data to a ground computer, and the Life Accounting Program element, which calculates the life expectancy of such hot section components as turbine blades and vanes on the basis of AIDS' measured gas path and rotational parameter data. O.C.

A85-41842

### EVALUATION OF ABRADABLE TURBINE SEAL BY FRICTION-WEAR TEST AND ENGINE PERFORMANCE TEST

T. NAKAMURA, Y. NISHIYAMA, H. HIRAKAWA, and N. WASADA (Kawasaki Heavy Industries, Ltd., Akashi, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 3. Tokyo, Gas Turbine Society of Japan, 1984, p. 743-748. refs

Friction-wear test at room temperature under simulated rub conditions and engine performance test have been done on candidate materials considered for use as abradable turbine seals in a small gas turbine engine. Wear ratio, radial load curve and rub debris size obtained from the friction-wear test have been the important factors to select the seal material. Selected seal materials have been confirmed to improve the turbine efficiency due to the minimized blade tip wear and tip clearance. Author

A85-41848

### ASPECTS OF MODERN MILITARY AERO ENGINES

J. SCHMIDT (Motoren- und Turbinen-Union Muenchen GmbH, Munich, West Germany) and J. A. HOOPER (Rolls-Royce, Ltd., Bristol, England) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 3. Tokyo, Gas Turbine Society of Japan, 1984, p. 847-857.

The technology development status of the RB 199 high performance low bypass turbofan is discussed, by way of illustration of the design features that are characteristic of state-of-the-art military aircraft powerplants, as well as the process of component uprating through which performance levels are continuously improved. The compressor, fan, core compressor and turbine sections of the engine are all subject to local performance improvements through design modification which result in overall efficiency gains. Also considered in this perspective are the contributions of turbine disk materials, oil and air systems, and digital control systems. The capabilities of next-generation engines are projected. O.C.

A85-41849

### RESEARCH AND DEVELOPMENT OF TURBOFAN ENGINE FJR710 - UPDATING

M. MATSUKI (Engineering Research Association for Aero-Jet Engines, Tokyo; Nippon Institute of Technology, Saitama, Japan) and H. TAKAGI (Engineering Research Association for Aero-Jet Engines, Tokyo, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 3. Tokyo, Gas Turbine Society of Japan, 1984, p. 859-866.

The high bypass turbofan engine designated FJR710/600 is a technology integration prototype which incorporates component technologies developed during an earlier phase of the Japanese government's National Research and Development Program.

Attention is presently given to the design features of the FJR710/600, which include ceramic-coated turbine blades and digital engine controls, and to the results of extensive airworthiness tests conducted to determine stability, endurance and reliability levels. The high altitude tests conducted have considered engine performance in in-flight starts and in icing conditions; ground tests have simulated bird strikes, inlet distortions, and cross winds, as well as determined noise and structural behavior. O.C.

A85-41851

### VIBRATION CHARACTERISTICS AND DYNAMIC STRESSES IN HOLLOW TURBINE BLADES

J. THOMAS and S. H. ABDULRAHMAN (Surrey, University, Guildford, England) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 3. Tokyo, Gas Turbine Society of Japan, 1984, p. 937-944. refs

The vibration characteristics and dynamic stresses in various configuration of hollow turbine blades is investigated theoretically and experimentally. A superparametric parabolic shell element is used in the analysis, and is shown to give far superior results than other elements. The effect of wall thickness, cross-sectional dimensions and length on the dynamic characteristics are explained in the paper. The dynamic stress distribution on the hollow blades show the points of maximum principal stresses which are dependent on the mode order. Hence the possible centres of fatigue cracks can be easily identified. Author

A85-41852

### SLIPPING BEHAVIOR AND FRETTING FATIGUE IN THE DISK/BLADE DOVETAIL REGION

T. HATTORI, S. SAKATA, and H. OHNISHI (Hitachi, Ltd., Research Laboratory of Mechanical Engineering, Tsuchiura, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 3. Tokyo, Gas Turbine Society of Japan, 1984, p. 945-952. refs

Slipping behavior and deformation of a disk/blade dovetail assembly are analyzed using a finite element method and a program is developed for these contact problems. To analyse with high accuracy it is necessary to use an exact frictional coefficient. This frictional coefficient is obtained through a complex loading test and includes any changes in the frictional coefficient occurring during cyclic loading. The blade damping capacity of this disk/blade dovetail assembly which is calculated from the calculated results of slipping behavior, and these results coincide well with those of other experimental results. The fretting fatigue strength is also estimated based on the calculated results of stress distribution on the contact surface. Finally, these calculated results are confirmed by the measurement of dovetail slot stresses under actual operating loading conditions. Author

A85-41853

### NONCONTACT MEASUREMENT OF ROTATING BLADE VIBRATIONS

M. ENDOH, Y. MATSUDA (National Aerospace Laboratory, Chofu, Japan), and M. MATSUKI (Nippon Institute of Technology, Saitama, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 3. Tokyo, Gas Turbine Society of Japan, 1984, p. 953-960. refs

A powerful noncontact measuring system of fan blade vibrations called FVMS has been developed and successfully applied in the research and development projects of advanced fan and turbofan engines. FVMS consists of optical blade-tip detectors on the periphery of the fan casing, signal processing/data acquisition subsystem and control/calculation/display subsystem. Software are devised to insure valid data and high handling qualities of the system. Vibration waveforms and amplitudes of all the blades can be displayed on a sub-realtime basis in the on-line monitoring mode. Off-line operational mode is also available for later analysis and review. Detailed description of FVMS concept, performance and hardware and software fabrication are presented, as well as some test results which show a satisfactory agreement with strain gage outputs. Author



A85-41854

**BLADE VIBRATION ON RADIAL IMPELLERS EXCITED BY ROTATING STALL-CELLS AND DURING SURGE**

U. HAUPT and M. RAUTENBERG (Hannover, Universitaet, Hannover, West Germany) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings, Volume 3. Tokyo, Gas Turbine Society of Japan, 1984, p. 961-968. DFG-supported research. refs

Blade vibration measurements have been carried out on a high pressure, high mass-flow centrifugal compressor to obtain information about the excitation mechanism. For the experimental investigation semiconductor strain gages and a multichannel telemetry transmission system were used. The stress calculation for the vibrating blade by means of the FE-method enabled the choice of the measuring-points on the blade. A wide research program was started with blade vibration measurements in different operating ranges of the compressor and with different types of diffusers. Special emphasis was laid on the investigation of dangerous blade excitation by the cells of rotating stall which could be observed in the speed range of  $n = 16,000$  rpm. The blade vibration stresses during surge were analysed considering the flow behavior in this instationary operating zone at a rotational speed of  $n = 14,000$  rpm and for the compressor without and with a vaned diffuser. Author

A85-41855

**A PARAMETRIC STUDY OF THE UNBALANCE VIBRATION OF THE ROTOR SUPPORTED IN A LIGHT, FLEXIBLE CASING**

T. MIYACHI (National Aerospace Laboratory, Chofu, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings, Volume 3. Tokyo, Gas Turbine Society of Japan, 1984, p. 969-976.

A parametric study was conducted on the unbalance vibration of simple rotor-casing system which consisted of a rotor with one disk at the center of the span, two bearings, a casing and its support structures. Mass ratio of the casing to the rotor, bearing stiffness ratio, support stiffness ratio and type of damping were changed within the ranges probable in turbomachines, and unbalance response was calculated. It was clear that the first and the second critical speeds and response factors change very widely with changes of above mentioned parameters. Squeeze film damper or elastomer damper in one of two bearings is effective for reducing high response factors at the first and the second critical speeds. However, the third critical speed and response factor are little affected by these dampers. Author

A85-42275

**MONITORING AND DIAGNOSING THE TECHNICAL CONDITION OF GAS-TURBINE ENGINES FROM VIBRATION PARAMETERS [KONTROL' I DIAGNOSTIROVANIYE TEKHNIЧЕСКОГО СОСТОЯНИЯ ГАЗОТУРБИННЫХ ДВИГАТЕЛЕЙ ПО ВИБРАЦИОННЫМ ПАРАМЕТРАМ]**

S. M. DOROSHKO Moscow, Izdatel'stvo 'Transport', 1984, 129 p. In Russian. refs

The book is concerned with the practical problems associated with the use of monitoring and diagnostic techniques during the operation and repair of gas-turbine aircraft engines. Particular attention is given to the development of a vibroacoustic model of a gas-turbine engine, information content of vibration spectra, elastic and inertial properties of the monitored system, arrangement of vibrational transducers, and selection of control parameters. The principal characteristics of airborne vibration control systems for various types of gas-turbine engines are examined, as are methods of optimizing the diagnostic algorithms. V.L.

A85-42365\*#

Virginia Polytechnic Inst. and State Univ., Blacksburg.

**OPTIMIZATION OF CASCADE BLADE MISTUNING. I - EQUATIONS OF MOTION AND BASIC INHERENT PROPERTIES**

E. NISSIM (Virginia Polytechnic Institute and State University, Blacksburg) AIAA Journal (ISSN 0001-1452), vol. 23, Aug. 1985, p. 1213-1222. refs

(Contract NAG3-347)

Attention is given to the derivation of the equations of motion of mistuned compressor blades, interpolating aerodynamic coefficients by means of quadratic expressions in the reduced frequency. If the coefficients of the quadratic expressions are permitted to assume complex values, excellent accuracy is obtained and Padé rational expressions are obviated. On the basis of the resulting equations, it is shown analytically that the sum of all the real parts of the eigenvalues is independent of the mistuning introduced into the system. Blade mistuning is further treated through the aerodynamic energy approach, and the limiting vibration modes associated with alternative mistunings are identified.

O.C.

A85-42442#

**SOME OBSERVATIONS ON CIRCUMFERENTIALLY GROOVED CASING TREATMENT**

Z. LIU, C. ZHANG, J. SHI, Z. WANG, Z. WANG et al. Northwestern Polytechnical University, Journal, vol. 3, April 1985, p. 207-217. In Chinese, with abstract in English. refs

Three observations are presented which may help to explain the observed effects of circumferentially grooved casing treatment (CGCT), which is used to extend the stable operation region of a compressor. (1) Experimental evaluation of the overall rotor performance shows that CGCT for subsonic rotors can be designed by empirical rules applicable to CGCT for transonic rotors. (2) Correlation of experimental data with a given area-ratio parameter shows the validity of the concept of blockage area-ratio of a two-dimensional cascade in explaining the effectiveness of CGCT at the tip. (3) Comparison of the transient traces shows that CGCT may alter the unstable flow mode, tending to decrease the oscillatory flow energy. C.D.

A85-42671\*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

**FUTURE FUNDAMENTAL COMBUSTION RESEARCH FOR AEROPROPULSION SYSTEMS**

E. J. MULLEN (NASA, Lewis Research Center; U.S. Army, Propulsion Laboratory, Cleveland, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985, 7 p. Army-supported research. Previously announced in STAR as N85-27870. refs

(AIAA PAPER 85-1398)

Physical fluid mechanics, heat transfer, and chemical kinetic processes which occur in the combustion chamber of aeropropulsion systems were investigated. With the component requirements becoming more severe for future engines, the current design methodology needs the new tools to obtain the optimum configuration in a reasonable design and development cycle. Research efforts in the last few years were encouraging but to achieve these benefits research is required into the fundamental aerothermodynamic processes of combustion. It is recommended that research continues in the areas of flame stabilization, combustor aerodynamics, heat transfer, multiphase flow and atomization, turbulent reacting flows, and chemical kinetics. Associated with each of these engineering sciences is the need for research into computational methods to accurately describe and predict these complex physical processes. Research needs in each of these areas are highlighted. E.A.K.

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**A85-42672#**

### **A TURBINE ENGINE AERODYNAMIC MODEL FOR IN-STALL TRANSIENT SIMULATION**

K. CHUNG, K. R. LEAMY, and T. COLLINS (General Electric Co., Cincinnati, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 11 p. refs (AIAA PAPER 85-1429)

Attention is given to the analytical results obtained by means of a dynamic gas turbine engine model capable of simulating in-stall aerodynamic transients with high frequency response, accurate aerothermodynamic features, and the ability to implement stall recovery control strategies. This dynamic engine model was developed on the basis of a rigorous treatment of the governing equations, small control volumes, and time-step size. Transient simulations have been successfully run for the case of a high bypass turbofan engine configuration; inlet temperature distortion, in-flow bleed, and main burner fuel pulse were the factors used in the inducement of the stall phenomenon. Throttle chop and bleed door opening are the recoverability factors investigated. O.C.

**A85-43244#**

### **NUMERICAL CALCULATION OF FLOW FIELD IN AFTERBURNER DIFFUSER OF TURBOFAN ENGINE**

Y. CHEN (University of Science and Technology of China, Hefei, People's Republic of China) and C. SUN (Shengyan Aeroengine Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Feb. 1985, p. 49-56. In Chinese, with abstract in English. refs

The flow field in afterburner diffuser of a turbofan engine is calculated by the SIMPLE method. The results are compared with measured data. The computation shows that the profiles of the axial inlet velocity component and the values of the inlet turbulent energy have a considerable effect on the flow field in the diffuser. Therefore, in model or component tests it is necessary to guarantee the identity of the axial velocity profiles and the values of turbulent energy at the inlet of the test unit with those in the corresponding position of the actual engine. The variation of the flow field with velocities of the engine on the ground and in flight is researched by the present method. It is shown that the bypass ratio is the primary cause of the variation of the flow field. Author

**N85-29955\*#** Pratt and Whitney Aircraft Group, East Hartford, Conn. Engineering Div.

### **ENERGY EFFICIENT ENGINE HIGH-PRESSURE TURBINE COMPONENT RIG PERFORMANCE TEST REPORT**

K. P. LEACH May 1983 249 p refs  
(Contract NAS3-20646)  
(NASA-CR-168189; NAS 1.26:168189; PWA-5594-243) Avail: NTIS HC A11/MF A01 CSCL 21E

A rig test of the cooled high-pressure turbine component for the Energy Efficient Engine was successfully completed. The principal objective of this test was to substantiate the turbine design point performance as well as determine off-design performance with the interaction of the secondary flow system. The measured efficiency of the cooled turbine component was 88.5 percent, which surpassed the rig design goal of 86.5 percent. The secondary flow system in the turbine performed according to the design intent. Characterization studies showed that secondary flow system performance is insensitive to flow and pressure variations. Overall, this test has demonstrated that a highly-loaded, transonic, single-stage turbine can achieve a high level of operating efficiency. B.W.

**N85-29956\*#** Pratt and Whitney Aircraft Group, East Hartford, Conn.

### **ENERGY EFFICIENT ENGINE INTEGRATED CORE/LOW SPOOL TEST HARDWARE DESIGN REPORT**

J. W. BISSET and D. C. HOWE Mar. 1983 223 p refs  
(Contract NAS3-20646)  
(NASA-CR-168137; NAS 1.26:168137; PWA-5594-231) Avail: NTIS HC A10/MF A01 CSCL 21E

The National Aeronautics and Space Administration is sponsoring the Energy Efficient Engine Program to identify and

verify the technology required to significantly lower fuel consumption and operating cost for commercial gas-turbine engines. A major task that has been completed under this program is the design and analysis of test hardware for the integrated core/low spool. The integrated core/low spool is a test simulation of the conceptual study engine defined to meet the performance, economic and environmental goals of the Energy Efficient Engine Program. It is intended to permit evaluation and verification of critical technologies in a full engine operating environment. This report describes the design and results of design-related analyses for the integrated core/low spool and its subsystems. The design effort included a definition of the engine, major components, internal and external subsystems, test ducting, and test instrumentation. Various analytical representations, in addition to results acquired from supporting component rig and subscale model tests, have been used to verify aerodynamic and structural design concepts as well as to predict performance. Author

**N85-29957\*#** General Electric Co., Cincinnati, Ohio. Aircraft Engine Business Group.

### **ENERGY EFFICIENT ENGINE (E3) CONTROLS AND ACCESSORIES DETAIL DESIGN REPORT**

R. S. BEITLER and J. P. LAVASH Dec. 1982 158 p refs  
(Contract NAS3-20643)  
(NASA-CR-168017; NAS 1.26:168017; R82AEB400) Avail: NTIS HC A08/MF A01 CSCL 21E

An Energy Efficient Engine program has been established by NASA to develop technology for improving the energy efficiency of future commercial transport aircraft engines. As part of this program, a new turbofan engine was designed. This report describes the fuel and control system for this engine. The system design is based on many of the proven concepts and component designs used on the General Electric CF6 family of engines. One significant difference is the incorporation of digital electronic computation in place of the hydromechanical computation currently used. Author

**N85-29958\*#** Pratt and Whitney Aircraft, East Hartford, Conn. Commercial Products Div.

### **ENERGY EFFICIENT ENGINE COMPONENT DEVELOPMENT AND INTEGRATION PROGRAM Semiannual Status Report, 1 Oct. 1981 - 31 Mar. 1982**

30 Apr. 1982 160 p refs  
(Contract NAS3-20646)  
(NASA-CR-172846; NAS 1.26:172846; PWA-5594-202; SASR-8) Avail: NTIS HC A08/MF A01 CSCL 21E

The objective of the Energy Efficient Engine Component Development and Integration program is to develop, evaluate, and demonstrate the technology for achieving lower installed fuel consumption and lower operating costs in future commercial turbofan engines. Minimum goals have been set for a 12 percent reduction in thrust specific fuel consumption (TSFC), 5 percent reduction in direct operating cost (DOC), and 50 percent reduction in performance degradation for the Energy Efficient Engine (flight propulsion system) relative to the JT9D-7A reference engine. The Energy Efficient Engine features a twin spool, direct drive, mixed flow exhaust configuration, utilizing an integrated engine nacelle structure. A short, stiff, high rotor and a single stage high pressure turbine are among the major enhancements in providing for both performance retention and major reductions in maintenance and direct operating costs. Improved clearance control in the high pressure compressor and turbines, and advanced single crystal materials in turbine blades and vanes are among the major features providing performance improvement. Highlights of work accomplished and programs modifications and deletions are presented. B.W.

**N85-29959\*#** Bionetics Corp., Hampton, Va.  
**CIRCULATION CONTROL PROPELLERS FOR GENERAL AVIATION, INCLUDING A BASIC COMPUTER PROGRAM**  
 I. TABACK, A. L. BRASLOW, and A. J. BUTTERFIELD Apr. 1983 92 p refs  
 (NASA-CR-165968; NAS 1.26:165968) Avail: NTIS HC A05/MF A01 CSCL 01A

The feasibility of replacing variable pitch propeller mechanisms with circulation control (Coanada effect) propellers on general aviation airplanes was examined. The study used a specially developed computer program written in BASIC which could compare the aerodynamic performance of circulation control propellers with conventional propellers. The comparison of aerodynamic performance for circulation control, fixed pitch and variable pitch propellers is based upon the requirements for a 1600 kg (3600 lb) single engine general aviation aircraft. A circulation control propeller using a supercritical airfoil was shown feasible over a representative range of design conditions. At a design condition for high speed cruise, all three types of propellers showed approximately the same performance. At low speed, the performance of the circulation control propeller exceeded the performance for a fixed pitch propeller, but did not match the performance available from a variable pitch propeller. It appears feasible to consider circulation control propellers for single engine aircraft or multiengine aircraft which have their propellers on a common axis (tractor pusher). The economics of the replacement requires a study for each specific airplane application. Author

**N85-29960\*#** Scientific Systems, Inc., Cambridge, Mass.  
**NONLINEAR GLOBAL STABILITY ANALYSIS OF COMPRESSOR STALL PHENOMENA**  
 H. RAZAVI Jun. 1985 105 p refs  
 (Contract NAS3-24089)  
 (NASA-CR-174908; NAS 1.26:174908; SSI-24089) Avail: NTIS HC A06/MF A01 CSCL 21E

Compressor stall phenomena are analyzed from the point of view of nonlinear control theory, based on bifurcation-catastrophe techniques. This new approach appears promising and offers insight into such well-known compressor instability problems as surge and rotating stall and suggests strategies for recovery. Three interlocking dynamic nonlinear state space models are developed. It is shown that the problem of rotating stall can be viewed as an induced bifurcation of solution of the unstalled model. Hysteresis effects are shown to exist in the stall/recovery process. Surge cycles are observed for some critical parameter values. The oscillatory behavior is seen to be due to development of limit cycles, generated by Hopf bifurcation of solutions. More specifically, it is observed that at certain critical values of parameters, a family of stable limit cycles with growing and then diminishing amplitudes is generated, then giving rise to an unstable family of limit cycles. This unstable family in turn bifurcates into other unstable families. To further illustrate the utility of the methodology, some partial computation of domains is carried out, and parameter sensitivity analysis is performed. Author

**N85-29961#** Detroit Diesel Allison, Indianapolis, Ind. Engineering Dept.  
**ADVANCED GAS TURBINE (AGT) TECHNOLOGY PROJECT Semiannual Report**  
 Mar. 1984 94 p  
 (Contract DEN3-168; DE-AE01-77CS-51040)  
 (NASA-CR-174798; DOE/NASA/0168-8; NAS 1.26:174798; EDR-11682) Avail: NTIS HC A05/MF A01 CSCL 21E

Significant development activity occurred during the July to December 1983 period in the Allison-Pontiac AGT 100 Advanced Gas Turbine Technology Project. Two engines were evaluated through dynamometer testing. Through 1983, total accumulated engine test time (burning) was 41 hr 19 min. Engine D-2 incorporated a modification to the interface system between the ceramic regenerator bulkhead and power turbine scroll assembly, solving the problem of cracked bulkheads experienced on the last builds of engine D-1. A design modification was defined to eliminate the tendency to leak hot gas from the engine flow path

into the gearbox vent cavity. Compressor aerodynamic analyses that identified impeller modifications for improved performance were completed. These near-term improvements will be tested next period on a compressor rig. Two turbine aerodynamic improvements were designed for 1984 implementation: improved gasifier vane shape and a reduced capacity power turbine. Combustor development included rig changes to better simulate the engine flow path and to provide viewing stations for use of optical pyrometers. Rig testing was conducted to proof-test ceramic units, to examine starting and igniter relocations, and to map stability limits. Regenerator testing evaluated 23 disk/seal combinations in 145 hr of hot rig testing. Advanced concepts included a silicone leaf seal, polyimide integral wearface and seal platform, different crossarm cooling systems, low-leakage aluminum silicate risks, and an extruded magnesium-aluminum silicate disk. Ceramic turbine rotor development experienced improvement in molding, baking, and sintering engine configuration rotors. Nineteen sintered alpha silicon carbide rotors were cold-spin tested to failure. Average burst speed was 94,930 rpm. R.J.F.

**N85-29962\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.  
**FAULT DETECTION AND ACCOMMODATION TESTING ON AN F100 ENGINE IN AN F-15 AIRPLANE**  
 L. P. MYERS, J. L. BAER-RIEDHART, and M. D. MAXWELL (Pratt and Whitney Aircraft, West Palm Beach, Fla.) Jul. 1985 15 p refs  
 Presented at AIAA/SAE/ASME 21st Joint Propulsion Conf., Monterey, Calif., 8-10 Jul. 1985  
 (NASA-TM-86735; H-1293; NAS 1.15:86735; PAPER-85-1294) Avail: NTIS HC A02/MF A01 CSCL 21E

The fault detection and accommodation (FDA) methodology for digital engine-control systems may range from simple comparisons of redundant parameters to the more complex and sophisticated observer models of the entire engine system. Evaluations of the various FDA schemes are done using analytical methods, simulation, and limited-altitude-facility testing. Flight testing of the FDA logic has been minimal because of the difficulty of inducing realistic faults in flight. A flight program was conducted to evaluate the fault detection and accommodation capability of a digital electronic engine control in an F-15 aircraft. The objective of the flight program was to induce selected faults and evaluate the resulting actions of the digital engine controller. Comparisons were made between the flight results and predictions. Several anomalies were found in flight and during the ground test. Simulation results showed that the inducement of dual pressure failures was not feasible since the FDA logic was not designed to accommodate these types of failures. Author

**N85-29963\*#** Massachusetts Inst. of Tech., Cambridge. Dept. of Aeronautics and Astronautics.  
**TURBINE BLADE-TIP CLEARANCE EXCITATION FORCES Final Report**  
 M. MARTINEZ-SANCHEZ and E. M. GREITZER 7 Jun. 1985 97 p refs  
 (Contract NAS8-35018)  
 (NASA-CR-171534; NAS 1.26:171534) Avail: NTIS HC A05/MF A01 CSCL 21E

The results of an effort to assess the existing knowledge and plan the required experimentation in the area of turbine blade tip excitation forces is summarized. The work was carried out in three phases. The first was a literature search and evaluation, which served to highlight the state of the art and to expose the need for an articulated theoretical experimental effort to provide not only design data, but also a rational framework for their extrapolation to new configurations and regimes. The second phase was a start in this direction, in which several of the explicit or implicit assumptions contained in the usual formulations of the Alford force effect were removed and a rigorous linearized flow analysis of the behavior of a nonsymmetric actuator disc was carried out. In the third phase a preliminary design of a turbine test facility that would be used to measure both the excitation forces themselves and the flow patterns responsible for them were

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conducted and do so over a realistic range of dimensionless parameters. Author

**N85-29964\*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### **LARGE-SCALE ADVANCED PROPPAN (LAP) PROGRAM Progress Report**

D. A. SAGERSE and S. G. LUDEMANN (Hamilton Standard, Windsor Locks, Conn.) 1985 28 p refs Presented at the 21st Joint Propulsion Conf., Monterey, Calif., 8-10 Jul. 1985; sponsored by AIAA, SAE, ASME, and ASEE (NASA-TM-87067; E-2637; NAS 1.15:87067; AIAA-85-1187) Avail: NTIS HC A03/MF A01 CSCL 21E

The propan is an advanced propeller concept which maintains the high efficiencies traditionally associated with conventional propellers at the higher aircraft cruise speeds associated with jet transports. The large-scale advanced propan (LAP) program extends the research done on 2 ft diameter propan models to a 9 ft diameter article. The program includes design, fabrication, and testing of both an eight bladed, 9 ft diameter propan, designated SR-7L, and a 2 ft diameter aeroelastically scaled model, SR-7A. The LAP program is complemented by the propan test assessment (PTA) program, which takes the large-scale propan and mates it with a gas generator and gearbox to form a propan propulsion system and then flight tests this system on the wing of a Gulfstream 2 testbed aircraft. E.A.K.

**N85-29966#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Technology Branch.

### **COMPRESSOR RESEARCH FACILITY F100 HIGH PRESSURE COMPRESSOR INLET TOTAL PRESSURE AND SWIRL PROFILE SIMULATION Final Report, Dec. 1980 - Nov. 1983**

W. W. COPENHAVER Wright-Patterson AFB, Ohio AFWAL Oct. 1984 285 p refs (AD-A153911; AFWAL-TR-84-2030) Avail: NTIS HC A13/MF A01 CSCL 21E

The F100 gas turbine engine currently powers the F-15 and F-16 aircraft. The compression section of this engine consists of a three-stage fan followed by a ten-stage High Pressure Compressor (HPC). A component test of the F100 HPC will be performed in the Compressor Research Facility (CRF) of the Aero Propulsion Lab (APL) at Wright-Patterson AFB, to investigate its stall and post stall characteristics. This testing will require that the high pressure compressor entrance profiles be simulated to obtain results which correspond to actual engine operation. Since these entrance profiles had never been measured, a program was designed to experimentally measure the total and static pressure, temperature and flow angle profiles at the HPC entrance of an F100 Series 3 engine (F100(3)). Data acquisition methods and results of a test to obtain the engine profiles are detailed. The design and testing efforts to simulate these profiles through preswirl vanes and screens are also defined. The CRF F100 inlet hardware configuration detailed in this report provides adequate engine inlet profile simulations to assure that comparisons can be made between CRF F100 test results and the engine environment.

GRA

**N85-29967#** Naval Postgraduate School, Monterey, Calif. **MEASUREMENT OF TURBOFAN-TURBOJET THRUST FROM TAILPIPE STATIC PRESSURE M.S. Thesis**

T. W. GIVENS and J. A. LEMOINE Dec. 1984 64 p (AD-A154036; NPS67-84-019) Avail: NTIS HC A04/MF A01 CSCL 14B

While the most accurate method for measuring turbojet/turbofan thrust is mechanical, a more practical method is often desired since a mechanical device is costly and non-portable. An investigation was conducted to determine whether inferring thrust indirectly from pressure provides sufficient accuracy to justify its use as an alternate technique for determining uninstalled thrust. TF41 engine data were provided by the Naval Air Rework Facility at Jacksonville, Fla. The data consisted of a variety of engine parameters which had been recorded during routine post-maintenance performance tests plus an additional set of

tailpipe static pressure readings that had been obtained from a slave tailpipe used for this project. The engine data were combined and an ensemble plot of tailpipe static pressure versus thrust was produced for analysis. A curve fitting technique was then used to determine how well the parameter correlated with thrust. The results were tested statistically and found to be reasonable. Correlation between thrust and tailpipe static pressure was excellent. GRA

**N85-29968#** Department of the Navy, Washington, D. C. **OPACITY CONTROL TECHNIQUE FOR JET ENGINE TEST CELLS Patent Application**

R. E. GLASS, JR., inventor (to Navy) 25 Feb. 1985 11 p (AD-D011668; US-PATENT-APPL-SN-705760) Avail: NTIS HC A02/MF A01 CSCL 14B

An improvement for jet engine test cells calls for the introduction of heated ambient air into the jet engine exhaust to reduce the opacity of the vented exhaust. Introducing reasonable amounts of cool ambient air does not reduce opacity. Heating is provided by a manifold about the exhaust duct that draws in ambient air or that recirculate a part of the exhaust. This approach is effective and can modify existing structure without excessive cost. GRA

**N85-29969#** Department of the Air Force, Washington, D.C. **VARIABLE CYCLE ENGINE FOR HIGH ALTITUDE AIRCRAFT Patent Application**

G. D. BREWER, inventor (to Air Force) 6 Feb. 1985 13 p (AD-D011705; US-PATENT-APPL-SN-698720) Avail: NTIS HC A02/MF A01 CSCL 21E

This patent application discloses turboshaft engine which is modified to be able to operate as a turbojet or a turboprop by the movement of an annular slide valve that directs gas flow between a high pressure turbine and a low pressure turbine. GRA

**N85-31057\*#** Pratt and Whitney Aircraft, East Hartford, Conn. Commercial Products Div.

### **CREEP FATIGUE LIFE PREDICTION FOR ENGINE HOT SECTION MATERIALS (ISOTROPIC) Annual Report**

V. MORENO Aug. 1983 89 p refs (Contract NAS3-23288) (NASA-CR-168228; NAS 1.26:168228; PWA-5894-17; AR-1) Avail: NTIS HC A05/MF A01 CSCL 21E

The Hot Section Technology (HOST) program, creep fatigue life prediction for engine hot section materials (isotropic), is reviewed. The program is aimed at improving the high temperature crack initiation life prediction technology for gas turbine hot section components. Significant results include: (1) cast B1900 and wrought IN 718 selected as the base and alternative materials respectively; (2) fatigue test specimens indicated that measurable surface cracks appear early in the specimen lives, i.e., 15% of total life at 871 C and 50% of life at 538 C; (3) observed crack initiation sites are all surface initiated and are associated with either grain boundary carbides or local porosity, transgranular cracking is observed at the initiation site for all conditions tested; and (4) an initial evaluation of two life prediction models, representative of macroscopic (Coffin-Manson) and more microscopic (damage rate) approaches, was conducted using limited data generated at 871 C and 538 C. It is found that the microscopic approach provides a more accurate regression of the data used to determine crack initiation model constants, but overpredicts the effect of strain rate on crack initiation life for the conditions tested. E.A.K.

**N85-31062#** National Aerospace Lab., Amsterdam (Netherlands). Constructies en Materialen Hoofdafd.

### **GAS TURBINES: OPERATING CONDITIONS, MATERIAL SELECTION AND DEVELOPMENT**

A. J. A. MOM 19 Jul. 1983 53 p refs In DUTCH; ENGLISH summary Submitted for publication (NLR-MP-83046-U; B8476175) Avail: NTIS HC A04/MF A01

Stresses, temperatures, and the impact of the environmental conditions on corrosion and erosion in gas turbine components are reviewed. Material selection and application to compressor blading, combustion cans, disks and high temperature turbine blades and vanes are discussed. Trends in materials development,

including directionally solidified eutectics, oxide dispersion strengthened alloys, fiber reinforced superalloy composites, and ceramics are indicated. The introduction and development of directional solidification, single crystal blade processing, and powder metallurgy are considered. Author (ESA)

## 08

## AIRCRAFT STABILITY AND CONTROL

Includes aircraft handling qualities; piloting; flight controls; and autopilots.

## A85-40308#

**FLIGHT CONTROL SYSTEM TECHNOLOGY IN THE CIVIL TRANSPORT AIRCRAFT (AIRBUS-PROGRAM) - STATUS AND KEY POINTS OF NEW DEVELOPMENT REQUIREMENTS [FLUGSTEUERUNGS-SYSTEMTECHNOLOGIE IM ZIVILEN TRANSPORTFLUGZEUG (AIRBUS-PROGRAMM) - STAND UND SCHWERPUNKTE NEUER ENTWICKLUNGSANFORDERUNGEN]**

U. CARI (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 36 p. In German.

(DGLR PAPER 84-089; MBB-UT-15-84)

The present investigation attempts to provide a survey regarding the current state of technology with regard to flight control systems in civil transport aircraft, taking into account the A310 as representative aircraft. New systems and functional elements of flight control technology are discussed on the basis of the design for the A320. Attention is also given to functions and system/component technologies which might be of importance for new aircraft projects. It is pointed out that the key factor regarding the initiation of the considered developments has been provided by the advances in the technology of highly-integrated, efficient digital components, such as, for instance, memory units and microprocessors. Control signals related to the development of fly-by-wire applications are considered along with certification issues in the case of flight critical/crucial systems, the A310 roll control system, the A310 yaw/trim control system, the A320 electrical flight control system, aspects of A320 flap/slat actuation, and integrated functions of wing flight controls. G.R.

## A85-40313#

**FLIGHT TEST OF THE GUST-ALLEVIATION SYSTEM OLGA [FLUGERPROBUNG DES BOEENABMINDERUNGSSYSTEMS OLGA]**

H. BOEHRET (Dornier GmbH, Friedrichshafen, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 22 p. In German. (DGLR PAPER 84-094)

The results of flight tests of the open-loop gust-alleviation (OLGA) system being developed for the Do 228 light aircraft are reported. The operating principles and design of OLGA are reviewed and illustrated with diagrams, graphs, and photographs, summarizing the description of Boehret (1983), and the flight-test results are presented graphically. When combined with optimal structural filters, OLGA is found to significantly reduce gust-induced vertical accelerations in the 0.1-2.0-Hz range, where passenger susceptibility to airsickness is highest. It is recommended that yaw dampers and an active damping system for the fundamental vibration of the wing be incorporated along with OLGA to reduce the passenger discomfort associated with 4-8-Hz vertical accelerations and yaw. T.K.

## A85-40839#

**AIRCRAFT CONTROL INTEGRATION - METHODOLOGY AND PERFORMANCE IMPACT**

K. L. SMITH (General Dynamics Corp., Fort Worth, TX), W. B. KERR (United Technologies Corp., Pratt and Whitney Aircraft Group, West Palm Beach, FL), G. L. HARTMANN (Honeywell, Inc., Minneapolis, MN), and C. SKIRA (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 21 p.

(AIAA PAPER 85-1424)

Tomorrow's fighters will rely more and more on the propulsion system to provide forces and moments for the enhancement of flight control functions. For the envisaged employment of the propulsion system, it will be necessary to develop integrated flight/propulsion controls for an appropriate coordination of the control action among the flight, inlet, engine, and nozzle subsystems. In the Air Force's Design Methods for Integrated Control Systems (DMICS) program, a technical approach and methodology for designing integrated flight/propulsion control laws for an advanced tactical aircraft will be developed. The present paper is mainly concerned with a 24-month, four-phase program related to the DMICS program. Phase I centered around system requirements, taking into account the impact of integrated control and simulation requirements. Phase II includes problems of simulation and development, while phase III is related to control law development. The purpose of the final phase is the evaluation of the resulting control system. G.R.

## A85-40995#

**THE STATUS OF FLUTTER SUPPRESSION TECHNOLOGY USING ACTIVE CONTROLS**

T. KATAYAMA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 366, 1984, p. 383-393. In Japanese. refs

Developments in flutter suppression using active control technology (ACT) are surveyed. Research of the main wing of the B-52 in wind tunnel test, L-1011 flight test, DC-10 wind tunnel test, DAST ARW-1 flight test, and wind tunnel test of two-dimensional wings are analyzed. Flutter suppression of wing/store, for F-4, F-16 and YF-17 wind tunnel tests, and fighter flight tests are discussed. Current status of theoretical analyses of subsonic and transonic speeds, and control theory are described. S.H.

## A85-41014#

**FLIGHT CONTROL SYSTEMS AND SENSORS FOR AIR TRANSPORT**

S. KUKITA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 369, 1984, p. 544-552. In Japanese. refs

The functions of electronic flight control sensors and their operation system, together with the role of active control technology (ACT) for configuration optimization are discussed. The interdisciplinary design of aircraft as a combination of aerodynamics, ACT, structural requirements, and propulsion and control systems is stressed. The future potential of man-machine-interface information systems is analyzed. Block diagrams are included. S.H.

## A85-41015#

**FLIGHT CONTROL TECHNOLOGY IN TRANSPORT**

J. SUMITA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 369, 1984, p. 553-561. In Japanese. refs

Flight control technology employing active control technology includes the stability augmentation and control augmentation systems, maneuver load control (MLC), gust load alleviation (GLA), and relaxed static stability control (RSS). An autopilot system employing flight management system is characterized. Requirements in designing a flight control system and the calculation of a GLA system for a medium transport are described.

## 08 AIRCRAFT STABILITY AND CONTROL

Block diagrams of B-52-MLC and -RSS, and a GLA system are included. S.H.

**A85-41019#**

### **OPTICAL TECHNOLOGY FOR FLIGHT CONTROL SYSTEMS**

M. MAYANAGI Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 369, 1984, p. 583-593. In Japanese. refs

Optical applications to the flight control system including optical data bus, sensors, and transducers are analyzed. Examples of optical data bus include airborne light optical fiber technology (ALOFT), F-5E, YC-14, YA-7D, MIL-STD-1553 fiber optic data bus, and NAL-optic data bus. This NAL (National Aerospace Laboratory)-optic data bus (based on the MIL-STD-1553B) is applied to STOL, and its characteristics are stressed. Principles and advantages of optical pulse-digital transducers are discussed. S.H.

**A85-41529**

### **THE FLIGHT CONTROL REVOLUTION**

J. MOXON and H. HOPKINS Flight International (ISSN 0015-3710), vol. 128, July 6, 1985, p. 23-25.

While the hardware associated with navigation, communications, and warning systems has traditionally had to be accommodated after the configuration and performance capabilities of aircraft had been established, the orders-of-magnitude enhancements of computing power more recently experienced in avionics have fundamentally altered this relationship, rendering navigation and flight control technologies primary factors to be considered in design optimization studies of new aircraft. Attention is presently given to the major role of computer-based digital avionics systems in the design and resulting capabilities of the A320 next-generation airliner. O.C.

**A85-41530**

### **WINDSHEAR ESCAPE**

H. HOPKINS Flight International (ISSN 0015-3710), vol. 128, July 6, 1985, p. 35-38.

Attention is given to the simulator results of a windshear warning and recovery guidance system recently developed for commercial aircraft, such as the B 727 whose cockpit controls and flight characteristics are presently assumed. The system incorporates recovery logic and a means by which to warn pilots of windshear conditions during the early takeoff roll, or to direct rotation and climb maneuvers in shear conditions after the crew is committed to takeoff. Similar provisions are made for landing approaches. The warning and recovery system is predicated on the comparison of aircraft response to controls in still air with the actual behavior being actively monitored. O.C.

**A85-42438#**

### **ANALYSIS OF MISSILE CONTROL SYSTEM STABILITY WITH MONTE CARLO METHOD**

F. ZHOU and Y. LI Northwestern Polytechnical University, Journal, vol. 3, April 1985, p. 169-177. In Chinese, with abstract in English. refs

The stability of tactical missile control systems is analyzed using a new method which combines the Monte Carlo method with functions describing the characteristics of nonlinear elements. The amplitude of the input signal in the describing function is simulated by uniformly distributed random variables in an interval so chosen that the value of the amplitude may occur in both the linear and nonlinear ranges. Random variables are used to simulate the system parameters of the missile in flight. An early tactical missile system is used for a sample calculation. The results show that the method is powerful and reliable in the stability analysis of missile control systems with significant nonlinearities. C.D.

**A85-43220\*** Hughes Helicopters, Culver City, Calif.

### **THE USE OF ACTIVE CONTROLS TO AUGMENT ROTOR/FUSELAGE STABILITY**

F. K. STRAUB (Hughes Helicopters, Inc., Culver City, CA) and W. WARMBRODT (NASA, Ames Research Center, Moffett Field, CA) American Helicopter Society, Journal (ISSN 0002-8711), vol. 30, July 1985, p. 13-22. refs

The use of active blade pitch control to increase helicopter rotor/body damping is studied. Control is introduced through a conventional nonrotating swashplate. State variable feedback of rotor and body states is used. Feedback parameters include cyclic rotor flap and lead-lag states, and body pitch and roll rotations. The use of position, rate, and acceleration feedback is studied for the various state variables. In particular, the influence of the closed loop feedback gain and phase on system stability is investigated. For the rotor/body configuration analyzed, rotor cyclic inplane motion and body roll-rate and roll-acceleration feedback can considerably augment system damping levels and eliminate ground resonance instabilities. Scheduling of the feedback state, phase, and gain with rotor rotation speed can be used to maximize the damping augmentation. This increase in lead-lag damping can be accomplished without altering any of the system modal frequencies. Investigating various rotor design parameters (effective hinge offset, blade precone, blade flap stiffness) indicates that active control for augmenting rotor/body damping will be particularly powerful for hingeless and bearingless rotor hubs. Author

**N85-29970\*** Massachusetts Inst. of Tech., Cambridge. Lab. for Information and Decision Systems.

### **RESEARCH ON OPTIMAL CONTROL, STABILIZATION AND COMPUTATIONAL ALGORITHMS FOR AEROSPACE APPLICATIONS Final Report**

M. ATHANS May 1985 65 p. refs. Previously announced as N85-17603

(Contract NGL-22-009-124)

(NASA-CR-172528; NAS 1.26:172528; LIDS-FR-1418) Avail:

NTIS HC A04/MF A01 CSCL 01C

The research carried out in the areas of optimal control and estimation theory and its applications under this grant is reviewed. A listing of the 257 publications that document the research results is presented. Author

**N85-31063** Stanford Univ., Calif.

### **GROUND EFFECT ON HELICOPTER AERODYNAMICS AND STABILITY Ph.D. Thesis**

H. A. SABERI 1985 119 p

Avail: Univ. Microfilms Order No. DA8506251

The theoretical wake of a helicopter rotor in ground effect was investigated for steady flight condition. The necessary formulation describing the vortices released by helicopter blades in three dimensional space was developed. A free wake method for wake prediction in steady level flight was chosen, and the ground boundary condition was satisfied by considering an image for the wake below the ground at the same distance. Numerical damping was introduced to stabilize the wake, which has the tendency of going numerically unstable. For wake prediction and computation of the induced velocity at any point in the flow, a computer code was developed which can be used in ground effect as well as out of ground effect. The free wake approach requires tremendous computation time. Usage of the numerical damping and iteration on only the portion of the wake which had not yet converged resulted in faster convergence. Dissert. Abstr.

**N85-31064\*** Purdue Univ., Lafayette, Ind.

### **INTERACTIVE AIRCRAFT FLIGHT CONTROL AND AEROELASTIC STABILIZATION Semiannual Report, 1 Nov. 1984 - 30 Apr. 1985**

T. A. WEISSHAAR May 1985 20 p

(Contract NAG1-157)

(NASA-CR-176035; NAS 1.26:176035) Avail: NTIS HC A02/MF A01 CSCL 01C

An analytical model of a 3-D airfoil was used to study an optimization procedure formulated to enhance stability of an airfoil

through integrated structural and control synthesis. This procedure is discussed together with preliminary results. These results show that a sensitivity derivative approach utilizing structural parameters, weighting matrix parameters and optimal control parameters (in this case, the design airspeed) is effective in determining the best structural/control design. Author

## 09

### RESEARCH AND SUPPORT FACILITIES (AIR)

Includes airports, hangars and runways; aircraft repair and overhaul facilities; wind tunnels; shock tube facilities; and engine test blocks.

#### A85-40291#

**THE EXPERIENCE OF AN AIRPORT WITH FLIGHT SAFETY - ITS EFFECT ON AIRPORT INFRASTRUCTURE AND TRAFFIC SITUATION [ERFAHRUNGEN EINES FLUGHAFENS MIT DER FLUGSICHERUNG - IHRE AUSWIRKUNG AUF SEINE INFRASTRUKTUR UND VERKEHRSSITUATION]**

H. WEISS (Flughafen Friedrichshafen GmbH, Friedrichshafen, West Germany) DGLR and DGON, Symposium ueber die allgemeine Luftfahrt und Regional Luftverkehr-Bestandteile des Verkehrssystems, Friedrichshafen, West Germany, Mar. 26-29, 1985, Paper. 7 p. In German.

The introduction of ATC facilities at West German regional airports is discussed from the perspective of the airport operator, using the case of Friedrichshafen (30,000 flight movements per year) as an example. The governmental requirements for ATC airports are reviewed, and the advantages of ATC (increased traffic and numbers of passengers, increased safety) are shown to be nearly balanced by the disadvantages (cost of installations and personnel, more extended open hours, and passenger facilities; less flexibility of operation; complicated and expensive certification procedures). Arguments in favor of financial support (from regional and local governments) for regional-airport improvement and a more equitable allocation of airspace (vis a vis restricted military zones) are presented. T.K.

#### A85-40314#

**THE KRYO-KANAL KOELN (KKK) AS AN EXAMPLE OF A HIGHER-REYNOLDS-NUMBER WIND TUNNEL [WINDKANAELE HOEHERER REYNOLDSZAHLEN AM BEISPIEL DES KRYO-KANALS-KOELN /KKK/]**

G. VIEHWEGER (DFVLR, Brunswick, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 25 p. In German. refs (DGLR PAPER 84-095)

The fundamental principles, costs, and operational phases (cooldown, preparation, starting, measurement, rundown, and warming) of cryogenic wind tunnels are discussed, and the problems encountered in modifying the conventional low-speed wind tunnel at Cologne for cryogenic operation are discussed. Particular attention is given to the test section, the blowers and power plant, the liquid-N<sub>2</sub> system, the exhaust and safety system, and the interior insulation; and photographs, drawings, and diagrams are provided. The first trial operation of the KKK took place in September 1984, with calibration under cryogenic conditions scheduled for the second half of 1985. T.K.

## 09 RESEARCH AND SUPPORT FACILITIES (AIR)

#### A85-40315#

**STAGES IN THE DEVELOPMENT OF THE EXTERNAL WIND-TUNNEL BALANCE [ENTWICKLUNGSTUFEN DER EXTERNEN WINDKANALWAAGE]**

P. GIESECKE (Carl Schenck AG, Darmstadt, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 14 p. In German. (DGLR PAPER 84-096)

Recent progress in the design of external wind-tunnel balances is reviewed, with an emphasis on automotive applications. The main developmental steps discussed are the replacement of sliding-weight balances with standardized modular scales and the replacement of mechanical decoupling with computer decoupling. A third step, the application of the six-component single-platform scale (such as that now in use at the Deutsch-Niederlaendischer Windkanal) for automotive wind-tunnel measurements, is recommended. Diagrams, drawings, graphs, and photographs of typical installations and instruments are provided. T.K.

#### A85-40324#

**THE TRANSONIC WIND TUNNEL OF THE MUNICH INSTITUTE FOR AIR TRANSPORT TECHNOLOGY AND LIGHT CONSTRUCTION OF HSBW [DER TRANSSONISCHE WINDKANAL DES INSTITUTS FUEER LUFTFAHRTTECHNIK UND LEICHTBAU DER HSBW MUENCHEN]**

S. WAGNER and A. HAMPEL (Muenchen, Hochschule der Bundeswehr, Neubiberg, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 49 p. In German. refs (DGLR PAPER 84-107)

The transonic wind tunnel of HSBw Munich (TWM) is discussed. The tunnel specifications, control systems, computer control, measurement systems, and schlieren optics are addressed. The optimization of the measuring technique and flow quality are treated, taking into consideration issues such as the calibration procedure for the pressure probe and tunnel control using correction values. The functionality of the entire system and its ability to meet its design goals is demonstrated. The improvement of the tunnel's flow mechanical characteristics by various means is discussed. C.D.

#### A85-40325#

**FLEXIBLE, ADAPTIVE WALLS FOR TRANSONIC WIND TUNNELS IN THE SUBSONIC AND SUPERSONIC REGIONS [FLEXIBLE ADAPTIVE WAENDE FUEER TRANSSONIK-WINDKANAELE IM UNTERUND UEBERSCHALL]**

U. GANZER and R. REBSTOCK (Berlin, Technische Universitaet, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 15 p. In German. refs (DGLR PAPER 84-108A)

Problems arising during the adaptation of three-dimensional measurement sections of wind tunnels are discussed. It is shown how customary control methods using constant control factors have to be modified to guarantee a fast wall adaptation. Comparative calculations using a TSP procedure are used to demonstrate the usability of the panel method at high subsonic inflow Mach numbers, and a design method for calculating the wall deflection is presented. The use of adaptive wind tunnels in the supersonic range is discussed in detail. C.D.



## 09 RESEARCH AND SUPPORT FACILITIES (AIR)

A85-40326#

### NEW ADAPTIVE TEST SECTION FOR THE HIGH-SPEED WIND TUNNEL OF THE DFVLR GOETTINGEN [NEUE ADAPTIVE MESSSTRECKE FÜR DEN HOCHGESCHWINDIGKEITSKANAL DER DFVLR GOETTINGEN]

A. HEDDERGOTT, E. WEDEMEYER, and D. KUCZKA (DFVLR, Institut fuer experimentelle Stroemungsmechanik, Goettingen, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 28 p. In German. refs

(DGLR PAPER 84-108B)

During the last few years, requirements related to the conduction of interference-free wind-tunnel measurements in the transonic Mach number region have led to the development of wind-tunnel test sections with adaptive walls. In these test sections, the walls are adapted to the streamlines of the unlimited interference-free flow. The principles involved were first described by Sears (1974) and Ferri and Baronti (1973). The present paper is concerned with the new adaptive test section which has been established in a wind tunnel of the Aerodynamic Experimental Institution in Goettingen, West Germany. The design of this test section is based on a principle of three-dimensional wall adaptation which utilizes a thick-walled, arbitrarily deformable rubber tube. Attention is given to details regarding the principle of the adaptive walls, a description of the adaptive test section, the calibration of the test section without models, measurements of pressure distribution at models, and certain problems and their solution. G.R.

A85-40340#

### WIND-TUNNEL TECHNOLOGY FOR THE DEVELOPMENT OF FUTURE COMMERCIAL AIRCRAFT [WINDKANALTECHNOLOGIE FÜR DIE ENTWICKLUNG ZUKUNFTIGER VERKEHRSFLUGZEUGE]

J. SZODRUCH (Messerschmitt-Boelkow-Blohm GmbH, Bremen, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 33 p. In German. refs

(DGLR PAPER 84-127; MBB-UTE-2-1356)

Requirements for new technologies in the area of civil aircraft design are mainly related to the high costs involved in the purchase of modern, fuel-saving aircraft. A second important factor is the long-term rise in the price of fuel. The demonstration of the benefits of new technologies, as far as these are related to aerodynamics, will, for the foreseeable future, still be based on wind-tunnel measurements. Theoretical computation methods are very successfully used in design work, wing optimization, and an estimation of the Reynolds number effect. However, wind-tunnel tests are still needed to verify the feasibility of the considered concepts. Along with other costs, the cost for the wind tunnel tests needed for the development of an aircraft is steadily increasing. The present investigation is concerned with the effect of numerical aerodynamics and civil aircraft technology on the development of wind tunnels. Attention is given to requirements for the wind tunnel, investigative methods, measurement technology, models, and the relation between wind-tunnel experiments and theoretical methods. G.R.

A85-40535

### A FEDERAL PERSPECTIVE ON HELIPORT DEVELOPMENT

R. E. LIVINGSTON, JR. (FAA, Washington, DC) Vertiflite (ISSN 0042-4455), vol. 31, July-Aug. 1985, p. 48-54.

It is pointed out that, after 50 years of providing its worth, the helicopter has yet to gain full acceptance in the world aviation community. On the other hand, the helicopter industry has made great advances, and rotorcraft growth is expected to continue at a relatively high rate. It appears that the optimum utilization of the helicopter is prevented by the lack of strategically located heliports from which this versatile machine can operate. In particular, a broad system of city-center heliports is needed to permit the helicopter to utilize its unique advantage in being able to conduct landing and takeoff operations on the basis of restricted areas located in the very heart of the city or other confined sites. The present paper is concerned with efforts related to an establishment

of the needed heliports. Attention is given to the FAA Helicopter Operations Task Force, the Rotorcraft Master Plan, and a National Prototype Demonstration Heliport Program. Attention is given to heliports in Indianapolis, Los Angeles, New Orleans, and New York. G.R.

A85-40543

### PIPELINE CONTROL SYSTEM WITH HIGH SAFETY RELIABILITY

K. DOI, S. SUGAYA, T. ISHIYAMA, and H. MINATO (Nippon Kokan Co., Ltd., Tokyo, Japan) Nippon Kokan Technical Report - Overseas Edition (ISSN 0546-1731), Aug. 1984, p. 52-62. refs

The control system for the aviation fuel pipeline extending to New Tokyo International Airport has been completed and its performance confirmed through operation. Since it is specified in Japan that every pipeline system should be installed with special attention paid to its safety and reliability, high reliability of the present pipeline was achieved by adoption of a duplex computer system and two-directional telemeters and telecontrollers. As for the leak detection system, a new system configuration was introduced for pressure detection and flow difference detection to be made during operation to improve the detectability, and its performance was confirmed by leak simulation using the actual fluid. In order to quantitatively determine the reliability of the completed system, its availability was calculated by the FTA method. As a result, this system was found highly reliable.

Author

A85-40551

### FLIGHT SIMULATION TECHNOLOGIES CONFERENCE, ST. LOUIS, MO, JULY 22-24, 1985, TECHNICAL PAPERS

Conference sponsored by AIAA. New York, AIAA, 1985, 102 p. For individual items see A85-40552 to A85-40565.

Among the topics discussed are the use of a Dynamic Flight Simulator to evaluate F-14 flat spin environment pilot performance, simulator evaluation for the F/A-18 ski jump, crew input to system response, Harrier II training capabilities, generalized multistep integration formulae for real time digital formulation, flight simulation fidelity in a total G-force environment, and the control of the human centrifuge as a force-and-motion platform for a dynamic flight simulator. Also covered are human motion perception models for the optimization of flight simulator motion algorithms, a simulated IR model board, a ring-vortex downburst model for real time flight simulation of severe wind shears, a composite statistical method for modeling wind gusts, aircraft tactical environment simulations, and a new approach to rotor dynamics simulation. O.C.

A85-40554#

### AV-8B HARRIER II TRAINING CAPABILITIES

R. J. MUFFLER (McDonnell Aircraft Co., St. Louis, MO) IN: Flight Simulation Technologies Conference, St. Louis, MO, July 22-24, 1985, Technical Papers. New York, AIAA, 1985, p. 11-15. (AIAA PAPER 85-1734)

An evaluation is made of the training facilities that have been developed for U.S. marine pilots' transition to AV-8B harrier II operation. These are designated the Operational Flight Trainer (OFT) and Weapons Tactics Trainer (WTT). OFT is specifically concerned with the development of pilot skills associated with V/STOL; WTT has the complementary role of refining pilots' air-to-ground and air-to-air weapons delivery skills, especially those which involve low altitude navigation and target penetration. Attention is presently given to the OFT and WTT simulators' imagery display pilot fields-of-view. O.C.

**A85-40555#**

### **SIMULATING THE WORKS - FROM CREW INPUT TO SYSTEM RESPONSE**

R. A. WEEKS (Northrop Corp., Advanced Systems Div., Pico Rivera, CA) IN: Flight Simulation Technologies Conference, St. Louis, MO, July 22-24, 1985, Technical Papers. New York, AIAA, 1985, p. 16-21.

(AIAA PAPER 85-1738)

Design concepts and representative cases are presented for full mission simulations of highly complex and integrated airborne weapons systems. Attention is given to the modeling of airframe, vehicle subsystems, avionics, and the requisite environments; these may possess varying levels of fidelity to their real counterparts. While flight control and avionics systems are furnished in highly detailed form, in keeping with mission success and flight safety criteria, the subsystems models may have significantly less detailed level of definition. O.C.

**A85-40557#**

### **FLIGHT SIMULATION FIDELITY IN A TOTAL G-FORCE ENVIRONMENT**

D. E. BISCHOF, D. A. POOLE (Veda, Inc., Warminster, PA), and J. EYTH, JR. (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: Flight Simulation Technologies Conference, St. Louis, MO, July 22-24, 1985, Technical Papers. New York, AIAA, 1985, p. 29-36.

(AIAA PAPER 85-1741)

An evaluation of the Dynamic Flight Simulator (DFS) installed on the NAVAIRDEVCE human centrifuge was conducted to determine the capability of the DFS to simulate transient and steady state aircraft force and motion characteristics in a total G-force environment. The evaluation was performed in both fixed and moving base modes utilizing standard qualitative and quantitative flight test techniques. The DFS demonstrated exceptional visual and motion cues for out-of-control/spin conditions as well as the potential to be an effective research tool for a variety of high-G maneuvering tasks. High fidelity with F-14A airplane high angle of attack/spin conditions, was also demonstrated. Continued development of the DFS is necessary to optimize dynamic response of the centrifuge for specific high G maneuvering tasks. Author

**A85-40558#**

### **CONTROLLING THE HUMAN CENTRIFUGE AS A FORCE AND MOTION PLATFORM FOR THE DYNAMIC FLIGHT SIMULATOR**

R. J. CROSBIE (Veda, Inc., Warminster, PA) and D. A. KIEFER (U.S. Navy, Naval Air Development Center, Warminster, PA) IN: Flight Simulation Technologies Conference, St. Louis, MO, July 22-24, 1985, Technical Papers. New York, AIAA, 1985, p. 37-45.

(AIAA PAPER 85-1742)

The Naval Air Development Center's Dynamic Flight simulator has required the design of an appropriate control algorithm for its three degree-of-freedom centrifuge, in order to obtain a realistic sense of angular motion for the pilot of the simulated aircraft. The approach used in algorithm design emphasizes perceptual rather than physical realism. Experimentally derived mathematical models of the human proprioceptive system were invaluable during development and testing. The models thus obtained permitted the use of linear and angular acceleration cues in combination. Potential use of this method in the design of control algorithms for other motion platforms is discussed. O.C.

**A85-40563#**

### **A FLEXIBLE DESIGN FOR A GENERAL PURPOSE SIMULATION FACILITY**

A. C. CRUCE and S. A. ALEXANDER (U.S. Naval Air Test Center, Patuxent River, MD) IN: Flight Simulation Technologies Conference, St. Louis, MO, July 22-24, 1985, Technical Papers. New York, AIAA, 1985, p. 69-80.

(AIAA PAPER 85-1752)

The Naval Air Test Center has been using simulation to support flight test for over eight years in the Tactical Avionics and Software Test and Evaluation Facility (TASTEF). Recently, this facility has

undergone extensive redesign based on new requirements, new technology, and the experience gained with the original facility. This paper discusses the original and new facility architecture and components and discusses the reasons for the various changes and enhancements. The original facility was intended to support testing for a large variety of aircraft types and be capable of rapid reconfiguration to support multiple test programs simultaneously. Due to lessons learned and the application of new technology the new facility enhances these capabilities and greatly improves overall facility productivity. Author

**A85-40821#**

### **THE DYNAMIC DATA ANALYZER (DDA), AN AIRCRAFT AERO-PROPULSION DIGITAL ANALYSIS TOOL**

C. H. BOCCADORO, E. D. HOWE, D. L. BIENEMAN, and D. W. BERNARD (Northrop Corp., Aircraft Group, Hawthorne, CA) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 12 p. refs

(AIAA PAPER 85-1212)

This paper describes the Dynamic Data Analyzer (DDA) and its use in evaluating inlet flow distortions on scaled inlet/airframe models. Emphasis is placed on system operation, data processing, and data output. The DDA is a complete, stand-alone and transportable, digital data acquisition and computing system. It acquires, digitizes, and stores time-variant pressure signal data while computing dynamic distortion descriptors in real-time. Its data management system provides instant access to these data for tabulations and graphs. The DDA makes it possible to expeditiously close-the-loop with the engine manufacturer on inlet/engine compatibility, study time-variant flow phenomena, and evaluate and develop methods of assessing dynamic distortion. Author

**A85-40844#**

### **A SUMMARY OF AN AGARD ASSESSMENT OF TESTING TECHNIQUES FOR AIRCRAFT AFTERBODY FLOWS**

D. L. BOWERS and J. A. LAUGHREY (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 20 p. refs

(AIAA PAPER 85-1465)

The choice of wind tunnel testing techniques for aircraft afterbodies must include consideration of test objectives, available facilities, and model hardware. The present, comprehensive assessment of the state-of-the-art among these techniques notes that force balances must be used with great care in order to minimize corrections. Pressure area integration can be a viable alternative for afterbody force measurements if the configuration is not excessively complex and coverage in high pressure gradients is adequate. The wind tunnel support should be chosen with careful attention to the sting, wing-tip, and strut supports. O.C.

**A85-41066**

### **MODERNIZATION OF THE BRAUNSCHWEIG LOW-SPEED WIND TUNNEL [MODERNISIERUNG DES NIEDERGESCHWINDIGKEITS-WINDKANALS]**

G. KAUSCHE and H. OTTO (DFVLR, Brunswick, West Germany) DFVLR-Nachrichten (ISSN 0011-4901), June 1985, p. 29, 30. In German.

The extensive modifications undertaken to improve the performance and range of applications of the low-speed wind tunnel at DFVLR Braunschweig are reviewed, and preliminary results of the first calibration are reported. The tunnel was originally opened in 1961, and the modifications were completed in March 1983. The modified tunnel employs a working section of height 2.80 m and width 3.25 m which has slitted walls and can be operated as an open or closed circuit at maximum velocities 75 and 90 m/s, respectively. T.K.

## 09 RESEARCH AND SUPPORT FACILITIES (AIR)

**A85-41328\*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### **THE APPLICATION OF CRYOGENICS TO HIGH REYNOLDS NUMBER TESTING IN WIND TUNNELS. I - EVOLUTION, THEORY, AND ADVANTAGES**

R. A. KILGORE and D. A. DRESS (NASA, Langley Research Center, Hampton, VA) Cryogenics (ISSN 0011-2275), Aug. 1984, p. 395-402. refs

During the time which has passed since the construction of the first wind tunnel in 1870, wind tunnels have been developed to a high degree of sophistication. However, their development has consistently failed to keep pace with the demands placed on them. One of the more serious problems to be found with existing transonic wind tunnels is their inability to test subscale aircraft models at Reynolds numbers sufficiently near full-scale values to ensure the validity of using the wind tunnel data to predict flight characteristics. The Reynolds number capability of a wind tunnel may be increased by a number of different approaches. However, the best solution in terms of model, balance, and model support loads, as well as in terms of capital and operating cost appears to be related to the reduction of the temperature of the test gas to cryogenic temperatures. The present paper has the objective to review the evolution of the cryogenic wind tunnel concept and to describe its more important advantages. G.R.

**A85-41331#**

### **LANDING PATH REQUIREMENTS FOR INSTRUMENTAL AIR TRAFFIC AT REGIONAL AIRPORTS AND LANDING STRIPS [ANFORDERUNGEN AN LANDEBAHNEN FUER INSTRUMENTENFLUGBETRIEB AUF REGIONALFLUGHAEFEN UND VERKEHRSLANDEPLAETZEN]**

W. TOEPEL (Bayerisches Staatsministerium fuer Wirtschaft und Verkehr, Munich, West Germany) DGLR and Deutsche Gesellschaft fuer Ortung und Navigation, Symposium ueber die allgemeine Luftfahrt und Regionalluftverkehr, Friedrichshafen, West Germany, Mar. 28, 29, 1985, Paper. 12 p. In German.

Technical planning and operational requirements for airports involved in regional air traffic are briefly discussed. The present suitability of airports in the Federal Republic of Germany for regional air traffic is considered. The costs of making the airports suited to such use is briefly addressed. C.D.

**A85-41340\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### **AN EXTERNAL INSULATION SYSTEM FOR A CRYOGENIC WIND TUNNEL**

D. A. DRESS, P. L. LAWING, and R. A. KILGORE (NASA, Langley Research Center, Hampton, VA) IIR, ASME and AIChE, Cryogenics Symposium, 5th, New Orleans, LA, Dec. 9-14, 1984, Paper. 8 p. refs

The thermal insulation system of the 0.3-Meter Transonic Cryogenic Tunnel (0.3-m TCT) at the NASA Langley Research Center is described in text, photographs, and drawings. The system is designed to operate from room temperature down to about 77.4 K, the temperature of liquid nitrogen at 1 atmosphere. A detailed description is given of the primary insulation system which consists of glass fiber mats, a 3-part vapor barrier, and a dry nitrogen positive-pressure purge system. Also described are several secondary insulation systems required for the test section, actuators, and tunnel supports. An appendix briefly describes the original insulation system which is considered inferior to the one presently in place. Time required for opening and closing portions of the insulation system for modification or repair to the tunnel has been reduced, typically, from a few days for the original thermal insulating system to a few hours for the present system. Author

**A85-42591**

### **CHINA CONSIDERS JOINT DEVELOPMENT OF TRANSONIC WIND TUNNEL FACILITY**

C. COVAULT Aviation Week and Space Technology (ISSN 0005-2175), vol. 123, July 29, 1985, p. 55, 58, 59.

The present tour of U.S. representatives through the Chinese Aeronautical Research and Development Center has revealed

several wind tunnel testing facilities, including subsonic, transonic, hypersonic, and two-dimensional tunnels. The hypersonic wind tunnels have been used to test ballistic missile reentry vehicles. The laboratories toured also incorporated an instructional computer facility, a jet engine test stand and combustion laboratory, a structural fatigue and fracture laboratory, and solid rocket motor research facilities. China has expressed an intention to build an advanced transonic wind tunnel facility, perhaps in cooperation with West European research establishments. O.C.

**A85-42662#**

### **DEVELOPMENT OF A SIMULATOR FACILITY FOR HELICOPTER AIR-TO-AIR COMBAT**

M. S. LEWIS (U.S. Army, Aeroflightdynamics Directorate, Moffett Field, CA) and D. G. YEO (Software Systems, Inc., San Jose, CA) AIAA, Flight Simulation Technologies Conference, St. Louis, MO, July 22-24, 1985. 8 p.

(AIAA PAPER 85-1733)

A number of Computer Generated Imagery (CGI) modifications required to develop a simulation facility for low-level, one-on-one helicopter air combat are discussed. These modifications to the NASA Ames Vertical Motion Simulator (VMS) system allowed two aircraft to be independently piloted on a single CGI data base. Air combat simulation engagements were flown by test pilots in a highly realistic fashion. Author

**A85-42663#**

### **BOEING FLIGHT SIMULATOR APPROVAL PROCESS**

W. D. TAFS, JR. and J. N. KRAFT (Boeing Co., Seattle, WA) AIAA, Flight Simulation Technologies Conference, St. Louis, MO, July 22-24, 1985. 8 p.

(AIAA PAPER 85-1736)

Flight simulator approval programs carried out at the Boeing Co. and the FAA simulator approval process are discussed, with reference to specific examples of flight test cases and methods used in the Approval Test Guide to duplicate these data for verification of the simulator aerodynamics. Particular topics discussed include the Customer Training Center, the FAA advanced simulation plan, flight test data acquisition, and data quality improvements. The discussion also covers simulator data collection, test guide development, and data match examples. V.L.

**A85-42665#**

### **A MODERN AIR COMBAT DOME VISUAL SYSTEM**

R. E. BARRETTE, A. MORRIS, and J. BARIBEAU (CAE Electronics, Ltd., Montreal, Canada) AIAA, Flight Simulation Technologies Conference, St. Louis, MO, July 22-24, 1985. 6 p.

(AIAA PAPER 85-1747)

A modern air combat dome visual system design takes advantage of state-of-the-art techniques to provide optimum system performance with minimum capital and operating costs. The unique features of this system are digital control of servos via microprocessors, a single optical periscope projector for each target covering the full field of view, a generic HUD capable of being programmed to represent any modern fighter fire control system and an intelligent target with pilot-like flying qualities capable of being programmed with the dynamics of various aircraft. Author

**A85-42667#**

### **A DIGITAL INTERFACE FOR FLIGHT SIMULATOR COCKPITS**

D. C. TASHIRO, J. S. HENDERSON, and H. KAMETANI (Northrop Corp., Aircraft Div., Hawthorne, CA) AIAA, Flight Simulation Technologies Conference, St. Louis, MO, July 22-24, 1985. 4 p.

(AIAA PAPER 85-1755)

To keep pace with current and future sophisticated aircraft cockpits, Northrop developed a modular microprocessor-based interface for simulator cockpits. This allowed Northrop to integrate a modular interchangeable simulator cockpit as well as a new methodology in developing simulations. This is made possible by utilizing standard off-the-shelf microprocessor based equipment. Therefore minimal new design, fabrication and checkout were required. The heart of the system is an Intel 8080 Microprocessor with a standard Intel Bus (Multibus) and operating system (ISIS-II).

## 09 RESEARCH AND SUPPORT FACILITIES (AIR)

The system's electrical interface utilizes standard ribbon cables. The overall hybrid linkage interface was reduced in size by several orders of magnitude and expanded functional capability was obtained. Author

**A85-42890#**

### **SNATCHING HARRIER FROM THE AIR WITH SKYHOOK**

E. J. LERNER Aerospace America (ISSN 0740-722X), vol. 23, Aug. 1985, p. 28, 30.

The Skyhook, a smart, electronically guided crane, has been proposed for accommodating take-offs and landings of the Harrier VTOL aircraft from ships as small as 4000 tons. The pilot guides the Harrier to a 1 cu m space beneath a locking jack. IR emissions from the Skyhook head illuminate a tracking pattern for the jack sensors to scan and follow. The pattern scanned permits the Skyhook computer to calculate the relative position of the Harrier and move to lock-on. The Skyhook would keep itself steady through servohydraulic systems guided by processed accelerometer data. The crane then moves the Harrier into the same relative motions of the ship, during landing operations, before setting the jet on-board. M.S.K.

**A85-43051#**

### **INVESTIGATION OF THE DYNAMICS OF THE LIMIT MANEUVERS OF A HELICOPTER BY MEANS OF A FLIGHT SIMULATOR [BADANIE DYNAMIKI GRANICZNYCH MANEWROW SMIGLOWCA NA SYMULATORZE LOTU]**

Instytut Lotnictwa, Prace (ISSN 0509-6669), no. 99, 1984, p. 3-21. In Polish. refs

The paper describes the concept of a hybrid helicopter-flight simulator along with methods for using it to investigate the limit properties of a helicopter, especially in emergencies. A working test stand implementing the concept is described, and the test method is discussed. B.J.

### **N85-29973\*# Lockheed-Georgia Co., Marietta. CREW SYSTEMS AND FLIGHT STATION CONCEPTS FOR A 1995 TRANSPORT AIRCRAFT**

G. A. SEXTON Apr. 1983 427 p refs

(Contract NAS1-16199)

(NASA-CR-166068; NAS 1.26:166068; LG83ER0077) Avail: NTIS HC A19/MF A01 CSCL 14B

Aircraft functional systems and crew systems were defined for a 1995 transport aircraft through a process of mission analysis, preliminary design, and evaluation in a soft mockup. This resulted in a revolutionary pilot's desk flight station design featuring an all-electric aircraft, fly-by-wire/light flight and thrust control systems, large electronic color head-down displays, head-up displays, touch panel controls for aircraft functional systems, voice command and response systems, and air traffic control systems projected for the 1990s. The conceptual aircraft, for which crew systems were designed, is a generic twin-engine wide-body, low-wing transport, capable of worldwide operation. The flight control system consists of conventional surfaces (some employed in unique ways) and new surfaces not used on current transports. The design will be incorporated into flight simulation facilities at NASA-Langley, NASA-Ames, and the Lockheed-Georgia Company. When interfaced with advanced air traffic control system models, the facilities will provide full-mission capability for researching issues affecting transport aircraft flight stations and crews of the 1990s. Author

### **N85-29976# Department of the Navy, Washington, D. C. EXPEDIENT RUNWAY SURFACING WITH POST TENSIONING SYSTEM FOR EXPEDITIONARY AIRFIELDS Patent Application**

P. S. SPRINGSTON and R. L. CLAXTON, inventors (to Navy) 11 Feb. 1985 12 p  
(AD-D011677; US-PATENT-APPL-SN-702091) Avail: NTIS HC A02/MF A01 CSCL 01E

A portable airfield runway having anchored and tensioning system which is comprised of a plurality of fiberglass reinforced plastic panels anchored with earth anchors at each end of the runway is described. It uses self-contained hydraulic tensioning

and load maintenance units to maintain constant tension on the runway while allowing for both expansion/contraction due to temperature and dynamic aircraft braking loads. GRA

**N85-31065\*# Old Dominion Univ., Norfolk, Va. Dept. of Mechanical Engineering and Mechanics.**

### **SIDEWALL BOUNDARY-LAYER EFFECTS IN TWO-DIMENSIONAL AIRFOIL TESTING Progress Report, period ending Jun. 1985**

A. V. MURTHY and G. L. GOGLIA Jul. 1985 5 p refs

(Contract NAG1-334)

(NASA-CR-176034; NAS 1.26:176034) Avail: NTIS HC A02/MF A01 CSCL 14B

Theoretical studies required to evaluate and validate the streamlined wall test section of the 0.3 m transonic Cryogenic Tunnel were initiated. The various aspects that are being considered presently are deviations of the real wall shape from the true streamline shape, wall adjustment strategy, and the influence of the sidewall boundary layers. Since the top and bottom walls are supported at a finite number of jack points, the true wall shape will be different from the ideal streamline shape. This is determined by calculating the structural shape for cases for which the exact streamline shape can be calculated. For the structural shape calculations, the MSCNASTRAN code is being used. To start with, comparisons are made using simple singularities for model representation and also for a flat plate at angle of attack. Author

**N85-31068# Institut Franco-Allemand de Recherches, St. Louis (France).**

### **SHOCK WAVES IN ADJACENT ENGINE INLETS Final Report [STOSSWELLEN IN BENACHBARTEN TRIEBWERKSEINLAUFEN]**

G. PATZ 22 Feb. 1984 45 p refs In GERMAN

(Contract BMVG-T/R-760/D0017/D1717)

(ISL-R-104/84) Avail: NTIS HC A03/MF A01

Shock wave diffraction and propagation in two adjacent inlets is studied to get a general view of the effects on the flow in one open inlet. In a bidimensional test room divided into an inlet closed by a perforated plate and an open inlet, reflection shock waves with variable intensity were generated. The propagation and effects on the flow in the open inlet were studied at Mach numbers ranging from 0.6 to 0.7 to 1.6. Films and streak photographs made with a differential interferometer, and the measured values with a differential laser interferometer show a very weak shock wave in subsonic flow. The shock wave is not observed in supersonic flow. In both cases a perturbation caused by a transverse flow associated with a leading edge vortex separation of the partition wall between the two intakes is observed. Author (ESA)

### **N85-31069# European Space Agency, Paris (France). EXPERIENCES WITH THE USE OF A SIDE-STRUT MODEL SUPPORT SYSTEM FOR HIGH ANGLES FOR ATTACK IN THE TMK TRISONIK WIND TUNNEL**

H. ESCH Feb. 1985 53 p refs Transl. into ENGLISH of "Erfahr. mit einer Seitenhalter-Vorrichtung fuer hohe Anstellwinkel im Trisonikkanal TMK" Cologne Rept. DFVLR-Mitt-84-09, 1984 Original language doc. previously announced as N85-15763 (ESA-TT-895; DFVLR-MITT-84-09) Avail: NTIS HC A04/MF A01; original German version available from DFVLR, Cologne DM 22

Experience with a relatively simple model support system for high angles of attack in a blowdown wind tunnel are presented. The advantages of low production costs and low operational costs as compared to the standard system face the disadvantages of increased aerodynamic interference and asymmetrical deformations. Interference tests show the limitations of the use of this system. It can be used into the supersonic domain, especially for high Mach numbers. It is only conditionally usable in the transonic domain. Author (ESA)

## 09 RESEARCH AND SUPPORT FACILITIES (AIR)

**N85-31322#** San Antonio Air Logistics Center, Kelly AFB., Tex. Avionics Intermediate Shop Replacement Program.

### **F-111 AUTOMATIC TEST EQUIPMENT REPLACEMENT PROGRAM**

T. J. MACKEY *In* American Defense Preparedness Association Proc. of the Electron. Test Equipment Div.'s Ann. Program Rev. of Electron. Test Equipment Ind. Response to Emerging Defense Requirements p 76-82 1984

Avail: NTIS HC A09/MF A01 CSCL 14B

The F-111 avionics intermediate shop (AIS) test station replacement program is reviewed. This is a concept which embodied intermediate maintenance for this complex aircraft. The test stations which automatically test the aircraft for maintenance need to be replaced. This replaced concept is outlined. E.R.

## 10

## ASTRONAUTICS

Includes astronautics (general); astrodynamics; ground support systems and facilities (space); launch vehicles and space vehicles; space transportation; spacecraft communications, command and tracking; spacecraft design, testing and performance; spacecraft instrumentation; and spacecraft propulsion and power.

**A85-40913#**

### **ARIANE 4 HAS ALREADY 'FLOWN' IN WIND-TUNNELS AND OFF A SIMULATED LAUNCH PAD**

G. PATRI *Revue Aerospatiale* (ISSN 0065-3780), May 1985, p. 4-7. Translation.

Simulated test launches and wind tunnel trials with functioning scale models of the Ariane 4 launch vehicle are described. Aerodynamic forces have been assessed with stainless steel models in the Modane S2 and S3 wind tunnels, which have furnished airflows up to Mach 4. Particular attention has been given to the transition stage and stage separation effects. Scaled-down Viking engines have been employed in launch pad firing tests with a 1/20th scale model. Thermal and acoustic data have been acquired in simulated altitude conditions and with various vehicle attitudes. Pressure data have also been generated at simulated altitudes up to 60 km. M.S.K.

**A85-40914#**

### **HERMES - A COCKPIT INSPIRED BY THE AIRBUS A320**

G. PATRI *Revue Aerospatiale* (ISSN 0065-3780), May 1985, p. 8-11. Translation.

The cabin and cockpit design choices thus far made for the Hermes mini-Shuttle are discussed. The cabin will be a light alloy structure attached to the main airframe at four points. The total interior space will be about 26 cu m for two astronauts. Avionics and displays will feature fly-by-wire controls, five CRT symbolic displays for navigation, reentry and landing, and ergonomic engineering typified by the Airbus A320. A prime goal in the design is to automate the Hermes to the point where the astronauts' main function will be to order the machine to perform the flight and experiment operations. M.S.K.

**A85-42697#**

### **PARABOLIC AIRCRAFT FLIGHTS - AN EFFECTIVE TOOL IN PREPARING MICROGRAVITY EXPERIMENTS**

D. FRIMOUT and A. GONFALONE (ESA, Manned and Retrievable Systems Dept., Noordwijk, Netherlands) *ESA Bulletin* (ISSN 0376-4265), no. 42, May 1985, p. 58-63.

Aircraft parabolic flights have proved useful for allowing human intervention into short-term microgravity experiments. NASA uses a converted KC-135 to give researchers a microgravity environment 25 sec at a time. The flights, as happened with the Spacelab Fluid Physics Module, permit check-outs of hardware intended for space or examinations of phenomena previously observed in space. Up to 40 parabolas are flown per flight, with the number being

modified to fit the experiment manifest for the particular mission. A summary of ESA experiments conducted during a series of parabolic arcs is presented. M.S.K.

### **N85-30008# Naval Postgraduate School, Monterey, Calif. AN EXPERIMENTAL INVESTIGATION OF FUEL REGRESSION RATE CONTROL IN SOLID FUEL RAMJETS M.S. Thesis**

B. N. KO, Dec. 1984 63 p

(AD-A154251) Avail: NTIS HC A04/MF A01 CSCL 21B

An experimental investigation was conducted to examine fuel regression rate control methods other than variable bypass air flow rates in the solid ramjet. Air and oxygen injection at various axial locations within the fuel grain were examined as well as air, oxygen and ethylene injection through the step face. One inlet swirl design was also tested. Secondary gas injection was found to be inadequate for regression rate control. A small amount of inlet swirl resulted in a significant increase in fuel regression rate, indicating that variable inlet swirl may be a viable technique for providing in-flight fuel rate modulation in the solid fuel ramjet.

GRA

**N85-31072\*# Lockheed Missiles and Space Co., Sunnyvale, Calif.**

### **MISSION ANALYSIS OF SOLAR POWERED AIRCRAFT Final Report**

D. W. HALL, D. A. WATSON, R. P. TUTTLE, and S. A. HALL 30 Jul. 1985 54 p refs

(Contract NAS1-16975)

(NASA-CR-172583; NAS 1.26:172583) Avail: NTIS HC A04/MF A01 CSCL 22A

The effect of a real mission scenario on a solar powered airplane configuration which had been developed in previous work were assessed. The mission used was surveillance of crop conditions over a route from Phoenix to Tucson to Tombstone, Arizona. Appendices are attached which address the applicability of existing platforms and payloads to do this mission. Author

**N85-31105 Radio Technical Commission for Aeronautics, Washington, D. C.**

### **THE 121.5 MHZ ELT: PAST, PRESENT AND FUTURE**

B. J. TRUDELL and B. A. GEIER (FAA) *In* CNES Satellite Aided Search and Rescue. Exptl. Results and Operational Prospects p 183-194 1984 refs

Avail: CEPADUES, Toulouse

The high percentage of aircraft emergency locator transmitter false alarms (97%) is discussed. American regulations covering ELT design, installation, and power supplies are outlined.

Author (ESA)

**N85-31228# Societe Nationale Industrielle Aerospatiale, Paris (France). Div. Engins Tactiques.**

### **FLOW MODELING AT THE BASE REGION OF MISSILES [MODELISATION DE L'ECOULEMENT AU CULOT DES MISSILES]**

P. BERRUE, R. G. LACAU, and J. DELERY (ONERA, Paris) 1985 40 p refs *In* FRENCH Presented at 21st Colloq. d'Aerodyn. Appl. (AAAF), Lyon, 7-9 Nov. 1984

(SNIAS-851-320-101) Avail: NTIS HC A03/MF A01

The computation methods utilized to determine base drag are presented. The models apply to missiles flying at zero angle of attack, and equipped with an axisymmetric afterbody without fins. They can treat cases where the external flow is either supersonic or subsonic, with and without a central propulsive jet. The accuracy of the models is compared with experimental data. Limitations and developments are also discussed. Author (ESA)

## CHEMISTRY AND MATERIALS

Includes chemistry and materials (general); composite materials; inorganic and physical chemistry; metallic materials; nonmetallic materials; and propellants and fuels.

A85-40145

**DETERMINATION OF THERMAL STRESSES IN DIFFUSIONLESS HEAT-RESISTING COATINGS OF THE Ni(CO)CRALY SYSTEM**  
A. I. SAMOILOV, I. A. IGNATOVA, A. M. VOROBIEV, and V. S. KOZLOVA (Zavodskaja Laboratorija, vol. 50, Nov. 1984, p. 36-39) Industrial Laboratory (ISSN 0019-8447), vol. 50, no. 11, May 1985, p. 1078-1082. Translation. refs

Methods and results are reported for the determination and calculation using X-rays of the normal and shear stresses occurring during a processing cycle in a system consisting of ZhS6K creep-resistant alloy and a sprayed heat-resistant coating of the NiCrAlY type. A prismatic specimen is used to examine tendencies of the systematic stress state variation in relation to the geometry of the substrate and the thickness of the coating. The variation of the inherent thermal stresses along the length of a right-angled section of specimen coated on all sides with a coating of thickness  $\delta$  is determined. The calculations are performed by the method of superimposition of stresses using the principle of independence of the action of forces. C.D.

A85-40250

**MECHANICAL PROPERTIES OF ADVANCED TITANIUM POWDER METALLURGY COMPACTS**

F. H. FROES (USAF, Wright Aeronautical Laboratories, Materials Laboratory, Wright-Patterson AFB, OH), J. P. HERTEMAN, and D. EYLON (International Conference on Titanium, 5th, Munich, West Germany, Sept. 10-14, 1984) Powder Metallurgy International (ISSN 0048-5012), vol. 17, June 1985, p. 116-118. refs (Contract F33615-82-C-5078)

Advances are demonstrated in the manufacture of high strength powder metallurgy titanium alloys for gas turbines and airframes. Emphasis is given to two specific innovations: (1) plasma melting of Ti powders; and (2) hot isostatic pressing (HIP) of sintered bodies with a beta-matrix. The microstructure of Ti alloys manufactured using the above techniques are discussed, and experimental data are presented concerning the tensile strength and fatigue behavior of HIP material. It is shown that the tensile strength of HIP Ti alloys is at least comparable to forged materials, while fracture toughness and crack propagation characteristics of HIP Ti alloys are superior. Photomicrographs of a crack initiation site in HIP Ti-6Al-4V alloy are provided. I.H.

A85-40262#

**REQUIREMENTS AND DEMONSTRATION FOR AERONAUTICAL STRUCTURES MADE OF CARBON-FIBER-REINFORCED EPOXY RESINS [ANFORDERUNGEN UND NACHWEISFUEHRUNG FUER LUFTFAHRTSTRUKTUREN AUS KOHLENSTOFF-FASERVERSTAERKTEN EPOXIDHARZEN]**

A. HÄBEL (Bundesamt fuer Wehrtechnik und Beschaffung, Koblenz, West Germany) DGLR, Symposium ueber Entwicklung und Anwendung von CFK-Strukturen, Technische Universitaet Berlin, West Germany, Nov. 8, 9, 1984. 18 p. In German. refs (DGLR PAPER 84-149)

The demonstration of the airworthiness of an aircraft requires in the case of structural components, consisting of carbon-fiber-reinforced plastics, procedures which differ partly from those which have to be followed in the case of metal structures. The present investigation is concerned with the demonstration concept regarding the assurance of the airworthiness of structural components for the aeronautical equipment of the Armed Forces of West Germany, taking into account components made of carbon-fiber-reinforced epoxy resins. The structural properties which are characteristic for fiber composites are examined, taking

into account the anisotropy of the mechanical properties, the notched strength of the materials, degradation as a result of environmental factors, the scatter in the material strength, shock resistance, and fatigue strength. In a description of the test specifications, attention is given to dimensioning, the demonstration of structural integrity, lifetime, and the assurance of long-term characteristics. G.R.

A85-40320#

**NEW NONMETALLIC STRUCTURAL COMPOSITES FOR MILITARY-AIRCRAFT CONSTRUCTION [NEUE NICHTMETALLISCHE STRUKTURVERBUNDWERKSTOFFE IM MILITAERISCHEN FLUGZEUGBAU]**

H.-J. SEMRAU (Dornier GmbH, Friedrichshafen, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 35 p. In German. (DGLR PAPER 84-102)

The development of CFRP composites at Dornier for applications in military aircraft is surveyed and illustrated with diagrams, graphs, photographs, and tables of numerical data. The early history of DFRPs is traced; the prepreg-method fabrication and mechanical and technological properties of H795E-Celion-6000 are characterized in detail and demonstrated for the case of a high-temperature brake flap for the Alpha-Jet; the new generation of high-strength warm-formable weldable CFRPs based on thermoplastic matrices of high rupture elongation is described; and the use of high-strain carbon fibers in epoxy-matrix CFRPs with high impact resistance is considered. The extensive use of thermoplastic-matrix CFRPs in sheet form in future aircraft is predicted. T.K.

A85-40321#

**THE USE OF NONMETALLIC FIBER-REINFORCED COMPOSITES IN THE CONSTRUCTION OF CIVILIAN AIRCRAFT - THE CASE OF THE DO 228 [UEBER DEN EINSATZ VON NICHT-METALLISCHEN FASERVERBUND-WERKSTOFFEN IM ZIVILEN FLUGZEUGBAU AM BEISPIEL DER DO 228]**

G. ZIEGMANN (Dornier GmbH, Friedrichshafen, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 32 p. In German. refs (DGLR PAPER 84-103)

The use of fiber-reinforced composites in civilian aircraft (mainly to reduce fuel consumption and increase load capacity) and the technology of component fabrication are discussed, with a focus on the Do 228, where composites make up over 10 percent of the structural weight. The combinations of CFRP, aramid-fiber-reinforced-plastic, and metal components used in the wing and aileron structures of the Do 228 are shown, and criteria based on both fabrication considerations and mechanical properties are developed to aid in the selection of present available materials and to guide the development of advanced composites for specific applications. T.K.

A85-40922

**TITANIUM ALLOYS FOR HIGH TEMPERATURE APPLICATIONS - A REVIEW**

D. EYLON, S. FUJISHIRO, and F. H. FROES (USAF, Wright-Patterson AFB, OH) High Temperature Materials and Processes (ISSN 0334-1704), vol. 6, no. 1-2, 1984, p. 81-91. refs

The relationships between the high-temperature properties and chemistry of titanium alloys is discussed along with the processing, resulting microstructures, and protective coatings involving these alloys. Recent titanium alloy development is reviewed, and data are presented and discussed which illustrate the relationship between microstructure and mechanical properties and the oxidation resistance of the alloys. The application of these alloys in aerospace systems is addressed. C.D.

## 11 CHEMISTRY AND MATERIALS

**A85-41003#**

### **TITANIUM AND ITS ALLOYS FOR AEROSPACE**

T. NISHIMURA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 367, 1984, p. 433-446. In Japanese. refs

Preparation methods, characteristics, and applications of titanium materials to aerospace are reviewed. Mechanical properties of titanium alloys, such as tensile strength, hardness, Charpy value, and fatigue strength, are discussed. Titanium alloys used for jet engine components and airframes (Ti-6Al-4V, Ti-13V-11Cr-3Al, and Ti-6Al-6V-2Sn) are covered in detail. Future potential of titanium alloys for aerospace is discussed. S.H.

**A85-41004#**

### **HEAT RESISTANT ALLOYS FOR JET ENGINES AND HIGH STRENGTH STEELS FOR LANDING GEARS**

S. ISOBE Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 367, 1984, p. 446-455. In Japanese. refs

Recent developments in heat resistant alloys for turbine blades and disk materials, and steels for landing gears are surveyed. Ni-based superalloys such as 1480, Mar-M 200, Nasair 100, and Mar-M-247, and the oxide dispersion strengthened superalloys, MA 754 and MA 6000, are analyzed. Powder metallurgy employing rapid solidification rates to prepare superalloys (MERL 76 and APK 1) is discussed. Chemical composition of steel alloys used for landing gears, such as Maraging, 35NCD16, HP310, 4340M, and 4340, and tensile properties of these steels are listed. S.H.

**A85-41005#**

### **ADVANCED COMPOSITES - PRESENT STATUS AND FUTURE TREND**

A. KOBAYASHI Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 367, 1984, p. 455-463. In Japanese. refs

Current status and future potential of advanced composites are presented. Mechanical properties of fibers currently used for aerospace including E-glass, and carbon, boron, and aramid fibers, are discussed. Typical new composite materials included hybrid, oriented discontinuous fiber using SiC whisker, high temperature matrix of polyimide, and metal matrix with aluminum and fiber-reinforced titanium. Advantages of galvanic processes to prepare a metal matrix such as boron/Cu system are discussed. Developments of new aircraft using advanced composite materials, such as spanloader, multibody, and flatbed types, are described. Energy conservation of advanced composite materials is stressed. S.H.

**A85-41021#**

### **RECENT ADVANCES IN RESEARCH AND APPLICATIONS OF COMPOSITE MATERIALS IN AEROSPACE STRUCTURES**

T. ISHIKAWA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 370, 1984, p. 612-630. In Japanese. refs

Recent developments in composite materials for aerospace are reviewed, stressing fracture, joints, damage tolerance, and postbuckling problems. The molding process of polymer matrix composites is characterized. Super-heat-resistant polyimide, carbon/epoxy resin, and carbon/PEEK composite systems are compared. Specifications of the tail plane of the Boeing 737, constructed with carbon/epoxy (T300/5208), and its test program for the FAA certification are included. Applications of polymer matrix composite to Do-228 and the Space Shuttle are described. Current status in fiber reinforced metal and ceramics development and hybrid composites for aerospace are discussed. S.H.

**A85-41033#**

### **ENGINE MATERIALS**

Y. NISHIYAMA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 371, 1984, p. 724-731. In Japanese. refs

Materials for aircraft engines and materials design and processing methods are reviewed. Requirements and characteristic

properties of composite materials for constructing fans, compressor blades, turbine components including turbine disk, blade and nozzle, and combustor are discussed. Materials for fans and compressors include Al, Ti, and Ni alloys and stainless steel. Chemical composition of materials for gas turbine engines is presented. S.H.

**A85-41400**

### **POLYURETHANE PAINT SYSTEMS - HIGH SURFACE QUALITY [PUR-ANSTRICHSYSTEME OBERFLAECHEQUALITAET]**

HOHE

G. REINECK (Interflug Gesellschaft fuer Internationalen Flugverkehr mbH, Berlin, East Germany) Technisch-oekonomische Information der zivilen Luftfahrt (ISSN 0232-5012), vol. 21, no. 2, 1985, p. 75-77. In German.

The advantages of polyurethane (PU) paints for aircraft exteriors are reviewed, and application techniques are evaluated on the basis of experimental investigations. PU coatings are shown to be longer lasting; more resistant to chemicals, UV irradiation, particle erosion, extreme temperatures, and vibration effects; and significantly smoother (reducing friction drag and increasing airspeed) than acrylic-resin paints. Good results are obtained when the aircraft surface is cleaned first with a nonflammable organic solvent, then with a Vienna lime solution, and finally with a reactive chemical solution to produce a rough microporous layer on the Al surface prior to brush application of a wash primer or an epoxy primer and spray application of a 20-micron PU layer or a 13-18-micron epoxy layer (respectively) followed by the final 25-40-micron sprayed PU-paint coating. T.K.

**A85-41464**

### **FATIGUE CRACK GROWTH DUE TO PERIODIC UNDERLOADS AND OVERLOADS**

N. A. FLECK (Cambridge University, England) Acta Metallurgica (ISSN 0001-6160), vol. 33, July 1985, p. 1339-1354. refs

Fatigue cracks in steels and aluminum alloys can grow at a faster rate than predicted by a linear summation of damage, when they are subjected to certain types of load history. A number of mechanisms, including crack closure, can be invoked to explain this acceleration effect. An investigation into the influence of periodic underloads and overloads on crack growth response was conducted for BS4360 50B structural steel, BS1501 32A pressure vessel steel and 2014A-T4 aluminum alloy. A computer-controlled load shedding technique enabled tests to be run under stress intensity, K, control. It was found that cracks in all three materials grow at nearly twice the rate predicted by a Miner-type linear summation of damage. Measurements showed that crack closure does not account for these small changes in crack growth rate. A combination of other mechanisms leads to the accelerated growth. Author

**A85-41623**

### **DEVELOPMENTS IN AERO ENGINE MATERIALS**

D. DRIVER (Rolls-Royce Ltd., Derby, England) Metals and Materials (ISSN 0266-7185), vol. 1, June 1985, p. 345-354. refs

A comprehensive discussion is conducted concerning the metallic, composite and ceramic materials which have been developed to date for use in such major aircraft engine structural components as compressor disks and blades, axial compressor and turbine section stator vanes, and, most critically, turbine blades and disks. Attention is also given to the most promising prospects for strength/weight and strength/temperature improvements among such novel materials as metal-matrix aluminum composites, 'near-alpha' titanium alloys, and monolithic silicon carbide and nitride ceramics. Emphasis is given to the materials processing method-control of microstructural characteristics, which allows careful tailoring of substances for specific component applications. O.C.



A85-41624

**ALUMINIUM-LITHIUM BASED ALLOYS FOR AEROSPACE APPLICATIONS**

R. GRIMES, A. J. CORNISH, W. S. MILLER, and M. A. REYNOLDS (British Alcan Aluminium, Ltd., Chalfont, England) *Metals and Materials* (ISSN 0266-7185), vol. 1, June 1985, p. 357-363. refs

Aluminum-lithium alloys are likely to have considerable impact on the future design, manufacture and operating economics of aircraft. This article describes the development of this promising range of alloys, their metallurgy and likely future role in aerospace applications, particularly in the face of competition from nonmetallic composite materials. The authors emphasize that aluminum-lithium is capable of offering comparable weight savings to fiber reinforced materials whilst avoiding a radical departure from well-established technology and manufacturing practices. Author

A85-41841

**PERFORMANCE OF THERMAL BARRIER COATING FOR GAS TURBINE AIRFOIL IN ENGINE TEST**

H. TAKEDA, K. SHIMOTORI, T. SUZUKI (Toshiba Corp., Research and Development Center, Kawasaki, Japan), H. BABA (Toshiba Turbine Works, Yokohama, Japan), K. TAKAHARA (National Aerospace Laboratory, Mitaka, Japan) et al. IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 3. Tokyo, Gas Turbine Society of Japan, 1984, p. 737-741.

Effect and durability of thermal barrier coating (TBC) performed on the surface of a gas turbine high pressure first vane by plasma spraying was investigated in a 300 hour engine test. A 200 micron thick ZrO<sub>2</sub> ceramic layer was found to be effective as thermal barrier to give longer life to vane material which was under critical conditions during the test. No fatal TBC damage was observed after the test. TBC showed high durability to large strain induced by vane material deformation. To determine its durability further, a small tablet specimen thermal fatigue test was also performed. The role of the bond metal, which was arranged between ceramic layer and base metal, was emphasized for long range TBC durability. Author

A85-42571\*# Cornell Univ., Ithaca, N.Y.

**COMBUSTION EFFICIENCY OF A PREMIXED CONTINUOUS FLOW COMBUSTOR**

M. S. ANAND and F. C. GOULDIN (Cornell University, Ithaca, NY) *ASME, Transactions, Journal of Engineering for Gas Turbines and Power* (ISSN 0022-0825), vol. 107, July 1985, p. 695-705. refs (Contract NSG-3019)

Exhaust gas temperature, velocity, and composition measurements at various radial locations at the combustor exit are presented for a swirling-flow continuous combustor of a confined concentric jet configuration operating on premixed propane or methane and air. The main objective of the study is to determine the effect of fuel substitution and of changes in outer flow swirl conditions on the combustor performance. It is found that there is no difference in observed properties for propane and methane firing; the use of either of the fuels results in nearly the same exit temperature and velocity profiles and the same efficiency for a given operating condition. A mechanism for combustion is proposed which explains qualitatively the changes in efficiency and pollutant emissions observed with changing swirl. V.L.

A85-42753

**EFFECT OF INCLUSIONS ON TENSILE DUCTILITY OF A NICKEL-BASE OXIDE DISPERSION STRENGTHENED SUPERALLOY**

M. Y. NAZMY and R. F. SINGER (Brown Boveri et Cie. AG, Baden, Switzerland) *Scripta Metallurgica* (ISSN 0036-9748), vol. 19, July 1985, p. 829-832. refs

The effect of inclusion content on the ductility of the proprietary, oxide dispersion-strengthened nickel-base superalloy MA 6000 is studied. The effect is found to be describable by means of a single parameter, P, which is defined as the total projected length of inclusions/unit area on a plane parallel to that of fracture. The

magnitude of P is directly proportional to the volume fraction of inclusions, and inversely proportional to the inclusion dimension perpendicular to the fracture plane. Room temperature ductility is noted to decrease with increasing P. O.C.

A85-42934#

**PRELIMINARY INVESTIGATION OF THE STRENGTH AND DURABILITY OF SUPERPLASTIC FORMED ALUMINUM**

R. L. WILKINSON and R. K. CANNON (USAF, Flight Dynamics Laboratory, Wright-Patterson AFB, OH) (Structures, Structural Dynamics and Materials Conference, 25th, Palm Springs, CA, May 14-16, 1984, Technical Papers. Part 1, p. 498-502) *Journal of Aircraft* (ISSN 0021-8669), vol. 22, Aug. 1985, p. 692-696. Previously cited in issue 13, p. 1863, Accession no. A84-31678. refs

A85-43126

**PM AEROSPACE MATERIALS; PROCEEDINGS OF THE INTERNATIONAL CONFERENCE, BERN, SWITZERLAND, NOVEMBER 12-14, 1984. VOLUMES 1 & 2**

Conference sponsored by the Metal Powder Report. Shrewsbury, England, MPR Publishing Services, Ltd., 1984. Vol. 1, 523 p.; vol. 2, 317 p. For individual items see A85-43127 to A85-43165.

Among the topics discussed are aerospace applications of powder materials, processes for ultraclean metal powder production, the properties of melt-spun, prealloyed Ni-base powders, the degassing of alloy powders by vacuum heating, superalloy powder consolidation at atmospheric pressure, explosive compacting, results of hot consolidation for rapidly solidified Ni-base alloys, dispersion-strengthened Ni for gas turbine applications, isothermal forging of powder metallurgy superalloys, and novel Al-alloys for aerospace applications. Also discussed are the manufacture of rapidly solidified light alloy powders, the microstructure of rapidly solidified Al alloy powders produced by ultrasonic gas atomization, dispersion-strengthened Al extrusions, SiC whisker-reinforced Al alloys, silicon nitride for hot isostatic pressing, and ceramic-reinforced ceramics. O.C.

A85-43127

**RECENT DEVELOPMENTS AND TRENDS IN HIGH STRENGTH PM MATERIALS**

R. F. SINGER (Brown Boveri et Cie. AG, Baden, Switzerland) IN: *PM aerospace materials; Proceedings of the International Conference, Bern, Switzerland, November 12-14, 1984. Volume 1*. Shrewsbury, England, MPR Publishing Services, Ltd., 1984, p. 3-1 to 3-23. refs

Recent research and development results in powder metallurgy superalloys, titanium alloys, aluminum alloys, and ordered alloys are reviewed. Alloy development in combination with rapid solidification technology plays a dominant role. Of particular interest are aluminum alloys where improvements of high temperature strength have been obtained already with rapidly solidified Al-Fe-X alloys. Oxide dispersion strengthening continues to receive large interest because of its potential to increase strength without simultaneous loss of corrosion resistance. Powder metallurgy composite materials with discontinuous fiber reinforcement are possibly a low cost alternative to conventional composite materials. Interesting combinations of stiffness and strength have been achieved in SiC-whisker reinforced aluminum alloys. Development of low cost processing routes, e.g., for consolidation of powders, has been concentrated on superalloys, indicating the higher degree of maturation attained in this alloy system. Author

## 11. CHEMISTRY AND MATERIALS

**A85-43132**

### **DISPERSION STRENGTHENED NICKEL FOR GAS TURBINE APPLICATIONS**

R. W. FRASER (Sherritt Gordon Mines, Ltd., Research Centre, Fort Saskatchewan, Canada), S. G. BERKLEY (United Technologies Corp., Pratt and Whitney Group, East Hartford, CT), and B. HESSLER (Avco Corp., Lycoming Div., Stratford, CT) IN: PM aerospace materials; Proceedings of the International Conference, Bern, Switzerland, November 12-14, 1984. Volume 1. Shrewsbury, England, MPR Publishing Services, Ltd., 1984, p. 13-1 to 13-23. refs

DS Nickel is a wrought PM product of pure (99.9+) nickel containing a uniform dispersion of 10 to 30 nm thorium particles. Its most noteworthy characteristics compared with conventional nickel base superalloys are: higher melting point, higher thermal conductivity and better long term stability for its superior creep strength and stress-to-rupture properties at elevated temperature. The higher thermal conductivity minimizes temperature gradients and results in superior thermal fatigue resistance. These characteristics and its ability to be readily cold formed and coated with an oxidation/sulphidation resistant diffusion bonded surface of chromium-aluminum make it a suitable material for high temperature components in the combustion system of advanced gas turbine engines. The unique design, fabrication and assembly procedures that were developed to utilize DS Nickel for combustor components in the JT9D-7 and AGT1500 gas turbine engines are reviewed and over ten years of engine experience is summarized.

Author

**A85-43133**

### **SOME RECENT BELGIAN RESEARCH WORKS ON PM SUPERALLOYS**

M. LAMBERIGTS, E. DIDERRICH (Centre de Recherches Metallurgiques, Liege, Belgium), and F. BRANDT (Fabrique Nationale Herstal, S.A., Herstal, Belgium) IN: PM aerospace materials; Proceedings of the International Conference, Bern, Switzerland, November 12-14, 1984. Volume 1. Shrewsbury, England, MPR Publishing Services, Ltd., 1984, p. 14-1 to 14-21. Research supported by the Institut pour l'Encouragement de la Recherche Scientifique dans l'Industrie et l'Agriculture. refs

Several investigations were carried out to better understand metallurgical problems involved in the production of powder metallurgy (PM) superalloy turbine disks. Some of them focused on Astroloy, to evaluate distinct alloy chemistries, and assess the potential advantages of rapid solidification as regards microstructure, mechanical properties and hot workability. The best combination of characteristics was shown to derive from classically gas-atomized low carbon powders, consolidated by hot isostatic pressing (HIP) at 1150 C, and forged to near net shape below 1100 C. Satisfactory properties could moreover be already achieved in the as HIPed condition. The comparison of other competitive alloys revealed some metallurgical similarity between U 700 and Rene95 on the one hand, and between Merl 76 and IN 100, on the other hand, although distinct behaviors were observed in stress rupture and low cycle fatigue strengths. As a matter of fact, the latter depend more than tensile properties on those microstructural features which differ from alloy to alloy (gamma-prime fineness, carbide precipitation, etc.).

Author

**A85-43137**

### **MICROSTRUCTURES AND PROPERTIES OF HIP, HIP PLUS FORGED AND EXTRUDED P/M SUPERALLOY FGH95**

L. LI, S. Z. YANG, and J. X. QIANG (Central Iron and Steel Research Institute, Beijing, People's Republic of China) IN: PM aerospace materials; Proceedings of the International Conference, Bern, Switzerland, November 12-14, 1984. Volume 1. Shrewsbury, England, MPR Publishing Services, Ltd., 1984, p. 24-1 to 24-15.

The purpose of this work was to study the effects of various consolidation processes on the microstructures and properties of a P/M nickel-base superalloy FGH95, thus determining the optimum manufacturing process of turbine discs. The argon-atomized powder of FGH95 was consolidated by three different techniques: hot isostatic pressing (HIP), HIP + forge, and hot extrusion. The

microstructures and mechanical properties of all the consolidated billets have been studied. SEM and TEM examination shows beneficial microstructure changes resulting from forging and extrusion. The fracture surface exhibits interparticle failure for HIPed compacts owing to the formation of prior particle boundaries (PPBs), which impair mechanical properties. However, in the case of HIP + forged or extruded materials, the PPBs have been eliminated, thus exhibiting transgranular ductile failure. The beneficial effects of forging and extrusion on the mechanical properties are shown in this report.

Author

**A85-43141**

### **HIGH STRENGTH AND ELEVATED TEMPERATURE PM ALLOY FORGINGS FOR AEROSPACE APPLICATIONS**

G. W. KUHLMAN (Alcoa, Forging Div., Cleveland, OH) IN: PM aerospace materials; Proceedings of the International Conference, Bern, Switzerland, November 12-14, 1984. Volume 1. Shrewsbury, England, MPR Publishing Services, Ltd., 1984, p. 29-0 to 29-24. refs

Advanced prealloyed aluminum powder metallurgy alloys have emerged from over fifteen years of research and development to satisfy critical aerospace applications. The first generation high strength P/M alloys, 7090 and 7091, have been found to provide increased strengths and equivalent or superior corrosion resistance in forgings when compared to current ingot melted high strength alloys in use. A new advanced 7XXX high strength aluminum alloy, designated CW67, offers equivalent high strengths to alloy 7090, but double the fracture toughness of 7090 and significantly improved fracture toughness in comparison to the I/M alloys. The first generation elevated temperature P/M aluminum alloy, designated CU78, has demonstrated elevated temperature properties superior to existing cast and/or wrought aluminum alloys making it potentially competitive with titanium alloys in certain applications.

Author

**A85-43143**

### **DISPERSION STRENGTHENED ALUMINIUM EXTRUSIONS**

V. ARNHOLD (Sintermetallwerk Krebssoege GmbH, Radevormwald, West Germany) and J. BAUMGARTEN (J & A Erbsloeh, Velbert, West Germany) IN: PM aerospace materials; Proceedings of the International Conference, Bern, Switzerland, November 12-14, 1984. Volume 1. Shrewsbury, England, MPR Publishing Services, Ltd., 1984, p. 31-1 to 31-20. BMFT-supported research. refs

The potential of dispersion strengthening with nonmetallic dispersoids is based on the good mechanical properties and excellent microstructural stability at elevated temperatures. With reaction milling, powder metallurgy offers a process of adjusting a balanced ratio of carbide and oxide dispersoids in aluminium. The powders are compacted to billets and hot extruded. Material properties as a function of dispersoid content and composition and possible fields of application are discussed.

Author

**A85-43151**

### **THE TECHNOLOGY OF HOT ISOSTATIC PRESSING WITH REFERENCE TO SILICON NITRIDE**

J. HEINRICH and M. BOEHMER (DFVLR, Cologne, West Germany) IN: PM aerospace materials; Proceedings of the International Conference, Bern, Switzerland, November 12-14, 1984. Volume 1. Shrewsbury, England, MPR Publishing Services, Ltd., 1984, p. 42-1 to 42-14. refs

Two techniques, powder-bed canning (PBC) and the sinter canning (SC), used in the hot isostatic pressing (HIP) process in manufacturing ceramic parts of vehicular turbines are described. Both production lines, when silicon nitride is the matrix of choice, start with silicon powder compacts, followed by nitridation. In the production of such small complex shape parts as turbine blades, the PBC technique is employed, in which the porous parts are imbedded into BN powder, then vacuum-sealed into a glass (fused silica or Vidor) tube before HIP. Nonreactive BN prevents formation of a matrix-glass diffusion layer. In manufacturing larger parts like turbochargers or monolithic rotors, the more economic SC technique is used: the part is encapsulated first into an 'interface' layer, specific to the matrix, followed by a layer which contains

sintering additives. Both techniques allow economic production of HIPed parts from Si<sub>3</sub>N<sub>4</sub> and other ceramic materials with high strength and good temperature properties. I.S.

**A85-43153**

**POWDER MATERIALS AND CERAMICS IN AEROSPACE APPLICATIONS - A EUROPEAN PERSPECTIVE**

G. W. MEETHAM (Rolls-Royce, Ltd., Derby, England) IN: PM aerospace materials; Proceedings of the International Conference, Bern, Switzerland, November 12-14, 1984. Volume 2. Shrewsbury, England, MPR Publishing Services, Ltd., 1984, p. 1-0 to 1-14. refs

An evaluation is made of the development status of powder metallurgy and structural ceramics materials technologies applicable to high performance gas turbine engines, within the European industrial context. Attention is given to the prospective gains in turbine engine hot section efficiency obtainable through development of SiO<sub>2</sub>, Si<sub>3</sub>N<sub>4</sub>, Al<sub>2</sub>O<sub>3</sub>, SiC, ZrO<sub>2</sub>, W, and C consolidated-powder refractory materials as replacements for superalloy turbine blades and disks. Powder metallurgy superalloy turbine disk technology is noted to be the most mature, among those that are relevant to future operating temperature improvements through ceramic component development. O.C.

**A85-43157**

**HOT FORMING OF MECHANICALLY ALLOYED GAS TURBINE COMPONENTS**

E. GRUNDY, C. J. PRECIOUS, and D. PINDER (Incomap/Doncasters Monk Bridge, Ltd., Leeds, England) IN: PM aerospace materials; Proceedings of the International Conference, Bern, Switzerland, November 12-14, 1984. Volume 2. Shrewsbury, England, MPR Publishing Services, Ltd., 1984, p. 12-1 to 12-20. refs

A recent addition to the development of high temperature capability mechanically alloyed (MA) materials has been the utilization of forging and fabrication routes for the cost-effective production of gas turbine components. This paper covers the forming of the three commercial MA alloys for their main categories of application. These are Inconel alloy MA 754, by conventional forging for vanes and bands; Inconel alloy MA 6000, through conventional and isothermal forging for blades; and Incoloy alloy MA 956 (and MA 754), by ring rolling and metal spinning into combustor components. Other uses such as fuel nozzles and rotors are mentioned. Mechanical property comparisons of hot formed components are drawn with conventional MA mill products, and the control over structure and properties in these thermomechanically processing sensitive materials is discussed.

Author

**A85-43161**

**HIGH PERFORMANCE PM ALLOYS - THE PRICE OF ALLOWING FOR HIGH STRESSES IN COMPONENTS**

W. BETZ (Motoren- und Turbinen-Union Muenchen GmbH, Munich, West Germany) IN: PM aerospace materials; Proceedings of the International Conference, Bern, Switzerland, November 12-14, 1984. Volume 2. Shrewsbury, England, MPR Publishing Services, Ltd., 1984, p. 20-1 to 20-13. refs

The outstanding strength imparted to Ni-base superalloys by powder metallurgy processing techniques has led to a commensurate raising of design loads, with two significant consequences: this greater strength aggravated structural components' machining problems, requiring the development of novel machining tools and processes, and radicalized crack propagation from minor flaws as the limiting factor, so that surface finish and material purity became paramount considerations. These new problems call for a novel component life prediction concept in which the degree to which the continuum of material properties is disturbed is considered. O.C.

**A85-43224**

**HYGROTHERMALLY CURVATURE STABLE LAMINATES WITH TENSION-TORSION COUPLING**

S. J. WINCKLER (Rensselaer Polytechnic Institute, Troy, NY) American Helicopter Society, Journal (ISSN 0002-8711), vol. 30, July 1985, p. 56-58. refs

A design strategy to construct Hygrothermally Curvature stable Coupling (HTCC) laminates is presented. The laminates may be used in aeroelastic designs of helicopter rotor blades when tension coupling is required. The thermal curvature stability of the rotors is studied in a series of theoretical calculations. The theoretical properties of the HTCC are summarized. It is found that: (1) the HTCC laminates make possible strong tension-torsion coupling while maintaining hygrothermal curvature stability; (2) hygrothermal curvature stability is maintained independent of hygrothermal properties of individual layers within the laminate; and (3) the coupling strength is a continuous function of the angle parameter between zero and the upper limit. In addition to the theoretical study, several samples of HTCC laminate were investigated experimentally, and the results were used to confirm the theoretical calculations. I.H.

**N85-30032\*#** Lockheed-California Co., Burbank.

**FUEL CONTAINMENT AND DAMAGE TOLERANCE IN LARGE COMPOSITE PRIMARY AIRCRAFT STRUCTURES Contractor Report, Oct. 1981 - Jan. 1983**

C. F. GRIFFIN Mar. 1983 14 p refs Presented at the 6th Conf. on Fibrous Composites in Struct. Design, Jan. 1983 (Contract NAS1-16856)

(NASA-CR-166083; NAS 1.26:166083) Avail: NTIS HC A02/MF A01 CSCL 11D

Technical problems related to fuel containment and damage tolerance of composite material wings for transport aircraft was investigated. The major tasks are the following: (1) the preliminary design of damage tolerant wing surface using composite materials; (2) the evaluation of fuel sealing and lightning protection methods for a composite material wing; and (3) an experimental investigation of the damage tolerant characteristics of toughened resin graphite/epoxy materials. The design concepts investigated for the upper and lower surfaces of a composite wing for a transport aircraft are presented and the relationship between weight savings and the design allowable strain used within the analysis is discussed. Experiments which compare the fuel sealing characteristics of bolt-bonded joints and bolted joints sealed with a polysulphide sealant are reviewed. Data from lightning strike tests on stiffened and unstiffened graphite/epoxy panels are presented. A wide variety of coupon tests were conducted to evaluate the relative damage tolerance of toughened resin graphite/epoxies. Data from these tests are presented and their relevance to the wing surface design concepts are discussed.

E.A.K.

**N85-31291#** Societe Nationale Industrielle Aerospatiale, Toulouse (France). Direction Etudes.

**CORROSION IN CIVIL AIRCRAFT STRUCTURES [LA CORROSION DANS LES STRUCTURES D'AVIONS CIVILS]**

B. MIQUEL 18 Feb. 1985 21 p In FRENCH Presented at Surfair '84 Conf., Cannes, France, 26-28 Sep. 1984 (SNIAS-851-111-105) Avail: NTIS HC A02/MF A01

The problems of service life, minimum weight and optimum cost related to corrosion factors are discussed. Choice of structural materials and anticorrosion treatments are considered. Examples for the Caravelle, Concorde and Airbus are given. Trends in the utilization of new materials and surface corrosion protection are also discussed. Author (ESA)

## 11 CHEMISTRY AND MATERIALS

**N85-31304#** Societe Nationale Industrielle Aerospatiale, Suresnes (France).

### ELASTOMERS USED IN AERONAUTICS INDUSTRY [LES ELASTOMERES UTILISES DANS L'INDUSTRIE AERONAUTIQUE]

G. DALLEMAGNE 10 Jan. 1985 33 p In FRENCH Presented at Stage Mater. Nonmetal.

(SNIAS-851-551-103; CN-47.171) Avail: NTIS HC A03/MF A01

The physicochemical structure of elastomers is examined. The performance of various elastomers under specific conditions is given. Their uses in various aircraft components and systems are discussed. Classification and standardization procedures are also discussed together with the testing equipment employed and the results obtained. Author (ESA)

### **N85-31308#** Boeing Commercial Airplane Co., Seattle, Wash. DETAILED STUDIES OF AVIATION FUEL FLOWABILITY Final Report

H. K. MEHTA and R. S. ARMSTRONG Jun. 1985 95 p refs (Contract NAS3-24081)

(NASA-CR-174938; NAS 1.26:174938; D6-52996) Avail: NTIS HC A05/MF A01 CSCL 21D

Six Jet A fuels, with varying compositions, were tested for low temperature flowability in a 190-liter simulator tank that modeled a section of a wing tank of a wide-body commercial airplane. The insulated tank was chilled by circulating coolant through the upper and lower surfaces. Flow-ability was determined as a function of fuel temperature by holdup, the fraction of unflowable fuel remaining in the tank after otherwise complete withdrawal. In static tests with subfreezing tank conditions, hold up varied with temperature and fuel composition. However, a general correlation of two or three classes of fuel type was obtained by plotting holdup as a function of the difference between freezing point and boundary-layer temperature, measured 0.6 cm above the bottom tank surface. Dynamic conditions of vibrations and slosh or rate of fuel withdrawal had very minor effects on holdup. Tests with cooling schedules to represent extreme, cold-day flights showed, at most, slight holdup for any combination of fuel type or dynamic conditions. Tests that superimposed external fuel heating and recirculation during the cooldown period indicates reduced hold up by modification of the low-temperature boundary layer. Fuel heating was just as effective when initiated during the later times of the tests as when applied continuously. Author

**N85-31311#** Defence Research Establishment, Ottawa. (Ontario).

### A COMPARISON OF TWO BENCH SCALE TESTS OF FUEL LOW TEMPERATURE FLOW PROPERTIES

J. R. COLEMAN and L. D. GALLOP Jan. 1985 22 p In ENGLISH; FRENCH summary

(AD-A154477; DREO-920) Avail: NTIS HC A02/MF A01 CSCL 14B

The Setapoint apparatus, and a procedure originally developed by British Petroleum, are designed to give measure of the minimum temperature at which middle distillate fuels can be used. These were investigated, employing an experimental fuel, ERBS (Experimental Referee Broadened Specification) of petroleum origin, and synthetic mixtures based on isooctane with added n-paraffins. Special attention was given to the effects of cold flow improvers. GRA

### **N85-32024#** National Aeronautical Lab., Bangalore (India). R AND D ACTIVITIES OF THE MATERIALS SCIENCE DIVISION

A. K. SINGH In its R and D Programmes at the Natl. Aeron. Lab. p 27-57 1983 refs

Avail: NTIS HC A10/MF A01

Materials science research is discussed. The mechanical behavior of aircraft materials and structures, composite materials, and chemical analysis are discussed. The fatigue life evaluation of aircraft, crack growth and residual stress studies of combat aircraft, software development for fatigue analysis, and stochastic

modeling, and the synthesis of boron nitride are among the topics covered. R.J.F.

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Includes engineering (general); communications; electronics and electrical engineering; fluid mechanics and heat transfer; instrumentation and photography; lasers and masers; mechanical engineering; quality assurance and reliability; and structural mechanics.

**A85-40240**

### OPTIMAL STRUCTURAL DESIGN OF SHELLS - A SURVEY

J. KRUCZELECKI and M. ZYCZKOWSKI (Krakow; Politechnika, Poland) SM Archives (ISSN 0376-7426), vol. 10, no. 2, 1985, p. 101-170. refs

Recent papers devoted to the optimization of shell design are reviewed. Consideration is given to optimization criteria and design constraints for several shell designs, including shells of uniform strength; shells of uniform strength in a membrane bending state; reinforced shells; and ribbed (stiffened) shells. Shell design criteria are established for the plastic and elastic ranges of stress loading, as well as for fatigue strength, vibration, creep conditions, and aeroelastic stability. It is recommended that, in the future, more emphasis should be given to variational optimization of shells in stability conditions. I.H.

**A85-40254**

### THE INTERACTION OF A DIFFUSING LINE VORTEX AND AN ALIGNED SHEAR FLOW

D. W. MOORE (Imperial College of Science and Technology, London, England) Royal Society (London), Proceedings, Series A - Mathematical and Physical Sciences (ISSN 0080-4630), vol. 399, June 8, 1985, p. 367-375. refs

An exact solution of the Navier-Stokes equations of incompressible flow, which represents the interaction of a diffusing line vortex and a linear shear flow aligned so that initially the streamlines in the shear flow are parallel to the line vortex, is presented. If 'Gamma' is the circulation of the line vortex and 'nu' the kinematic viscosity then, when  $Re = \text{'Gamma'}/(2 \text{'pi' 'nu'})$  is large, the vorticity of the shear flow is expelled from the circular cylinder 0 less than r much less than  $1/(\text{'nu' t})$  to the  $(1/2)$  power/  $x/Re$  to the  $(1/3)$  power/, where r is the distance from the axis of the diffusing line vortex and t the time since initiation of the flow. At larger radii a peak vorticity  $0.903 \text{'Omega'}/Re$  to the  $(1/3)$  power/ is found at a radial distance  $1.26/(\text{'nu' t})$  to the  $(1/2)$  power/  $x/Re$  to the  $(1/3)$  power/, where 'Omega' is the initial uniform vorticity in the shear flow. The vortex filament is embedded in a growing cylinder from which vorticity has been expelled, the cylinder itself being bounded by an annular region of thickness of order  $1/Re$  to the  $(1/3)$  power/  $x/(\text{'nu' t})$  to the  $(1/2)$  power/ in which the vorticity is of order 'Omega' /Re to the  $(1/3)$  power/. G.R.

**A85-40277#**

### COMPARISON OF PREDICTIONS AND EXPERIMENTAL RESULTS ON NOTCHES AND BOLT-LOADED DRILLED HOLES IN CFRP LAMINATES [GEGENUEBERSTELLUNG VON VORHERSAGEWERTEN UND VERSUCHSERGEBNISSEN AN KERBEN UND BOLZENBELASTETEN BOHRUNGEN IN CFK-LAMINATEN]

J. BAUER (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) DGLR, Symposium ueber Entwicklung und Anwendung von CFK-Strukturen, Technische Universitaet Berlin, West Germany, Nov. 8, 9, 1984. 18 p. In German. (DGLR PAPER 84-141)

Theoretical models of the mechanical behavior of CFRP laminates near drilled holes are examined, and the results of

experimental tests on 914C/T300 specimens with open and loaded holes are reported. The problems imposed on aircraft designers by the present poor understanding of CFRP behavior in critical areas such as fuselage-wing joints are discussed and illustrated with drawings, and a theoretical approach based on the analysis of Savin (1966) and the characteristic-distance concept of Whitney and Nuismer, and employing a combination of fracture criteria, is developed. The experiments involve compression and tensile tests on open-hole specimens, bolt-loading tests, and interactive tests (compression and tensile tests with bolt loading). The theory is found to give good predictions for open holes and less satisfactory but conservative estimates for the bolt-loading and interactive tests. T.K.

#### A85-40289#

##### STATIC STRENGTH OF CARBON-FIBER-COMPOSITE FLAT BARS WITH UNSTRESSED HOLES [STATISCHE FESTIGKEIT VON CFK-FLACHSTAEBEN MIT UNBELASTETEN BOHRUNGEN]

K. SCHULTE, P. W. M. PETERS, V. BACHMANN, K. H. TRAUTMANN, and H. NOWACK (DFVLR, Institut fuer Werkstoff-Forschung, Cologne, West Germany) DGLR, Symposium ueber Entwicklung und Anwendung von CFK-Strukturen, Technische Universitaet Berlin, West Germany, Nov. 8, 9, 1984, Paper. 18 p. In German. refs

The use of carbon-fiber-reinforced plastic materials in the design of aircraft is steadily increasing. Advantages of the employment of these materials are partly related to the possibility to reduce the weight of the aircraft. However, the use of the composites makes it also possible to implement novel design features. Certain problems regarding the use of the considered plastic materials arise as a consequence of differences in the behavior of the composites compared to conventional structural materials. In comparison to metallic materials, the static strength of the reinforced plastics decreases significantly in the presence of notches or holes. The present investigation has the objective to obtain experimental data which can provide a basis for the prediction of the strength characteristics of carbon-fiber reinforced plastics with notches or holes. Laminated plastic specimens were subjected to tension and compression tests. The various factors which affect the strength of the specimens are discussed, taking into account laminate structure, specimen thickness, aging, and temperature. G.R.

#### A85-40305#

##### NEW PROCESSING TECHNIQUES FOR AUTOMATED CHEMICAL REMOVAL OF SURFACE METAL [NEUE FERTIGUNGSTECHNOLOGIEN BEIM AUTOMATISIERTEN CHEMISCH ABTRAGEN]

D. KOERNER (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 12 p. In German. (DGLR PAPER 84-085; MBB-UT-10-84)

Techniques developed at MBB to improve the efficiency and economy of the automated chemical etching of metal structures aircraft or spacecraft are surveyed, with a focus on mask application and cutting. The environmental, health, and economic disadvantages of spray application are summarized; the development of an immersion technique (immersion and removal from a 21-C bath of standard one-component air-drying masking paint at 1 m/min) to apply coatings of average thickness 250 microns to 2.5-m-high Al-alloy sheets is described; the 43-percent greater paint consumption of the immersion technique is shown to be balanced by a 75-percent time saving; and a CO<sub>2</sub> laser on a three-axis mount at cutting angles 45-90 deg and focal length 63.5 mm is shown to effectively remove the masking from curved objects without damaging the Al surface if operated at 100 W output power and cutting speed 10 m/min (or at proportionally lower speeds and powers). T.K.

#### A85-40306#

##### MODERN FORMING PROCEDURES FOR INTEGRAL STRUCTURAL COMPONENTS WHICH ARE STRENGTHENED BY STRINGERS OR RIBS [MODERNE UMFORMVERFAHREN FUER STRINGER- UND RIPPENVERSTEIFTE INTEGRALBAUTEILE]

R. MEYER (Dornier GmbH, Munich, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 26 p. In German. (DGLR PAPER 84-086)

The employment of integral structural components becomes increasingly important in comparison to the conventional 'differential' construction method which involves the joining of stringers, ribs, and covering components with the aid of rivets. Advantages of a use of integral structural components are related to a reduction in weight and lower manufacturing costs. Integral structural components forming a part of the covering of the structure, such as, for instance, the wing or fuselage covering skin, will have to be given a form which corresponds to the external contour. A description is given of a forming procedure employed in the case of a stringer-reinforced integral structural component for a modern European airliner. The forming procedure involves the blasting of the component surface with small steel balls. A similar approach had already been used for forming stringer-reinforced wing panels. Another forming procedure was employed for a component in a 'wing of novel technology'. This procedure is based on a compression technique. G.R.

#### A85-40358#

##### VECTOR CONTROL OF TWO-DIMENSIONAL TURBULENT FREE JET BY BOTH-SIDE FLAPS

K. ENOKIDA and T. OKAMOTO (Aoyama Gakuin University, Tokyo, Japan) JSME, Bulletin (ISSN 0021-3764), vol. 28, May 1985, p. 824-830. refs

This paper presents an experimental investigation of the characteristics of a two-dimensional turbulent jet deflected by the flaps attached at both sides of the nozzle. It was found that the deflection angle was nearly equal to the flap angle when the flap angle was less than the critical angle and it approached the deflection angle for one-side flap. And the length of potential core, decay of maximum velocity and spread of jet were varied with the flap angle, but were unchanged by the flap width. Author

#### A85-40560#

##### A SIMULATED INFRARED MODEL BOARD

C. E. JONES and J. LEE (Martin Marietta Aerospace, Orlando, FL) IN: Flight Simulation Technologies Conference, St. Louis, MO, July 22-24, 1985, Technical Papers. New York, AIAA, 1985, p. 52-56.

(AIAA PAPER 85-1748)

Martin Marietta Aerospace has built a model board that simulates infrared imagery for aircraft windscreens and sensor displays in its Simulation and Test Laboratory. The simulation uses an image isocon TV camera with a Farrand optical probe; the video output is 525 or 875-line monochrome forward-looking IR (FLIR) imagery. This paper outlines the design objectives, discusses the appearance of the simulated FLIR imagery on the displays, and describes the techniques used in constructing and painting the model board. Author

#### A85-40589

##### THE DEVELOPMENT OF EFFICIENT MODELS OF THE DEFORMATION OF THIN-WALL STRUCTURES [O POSTROENII EFFEKTIVNYKH MODELEI DEFORMIROVANNIA TONKOSTENNYKH KONSTRUKTSII]

I. F. OBRAZTSOV, B. V. NERUBAILO, V. N. ZAITSEV, and I. I. IVANOV (Moskovskii Aviatsonnyi Institut, Moscow, USSR) Prikladnaia Mekhanika (ISSN 0032-8243), vol. 21, June 1985, p. 61-67. In Russian. refs

Consideration is given to several approaches to developing efficient mathematical thin-wall deformation models and the application of numerical and analytical methods to determine the stress-strain states through discretization of thin-wall structures

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and through synthesis of stressed states. The study is carried out in the context of the application of the theory of shells and plates to airframe design. The approaches include the finite element method and some analytical methods which are most reliable in determining the stress-strain states. LT.

### A85-40730#

#### COMPUTATION OF INTERNAL INCOMPRESSIBLE SEPARATED FLOWS USING A SPACE-MARCHING TECHNIQUE

K. R. KIRTLEY and B. LAKSHMINARAYANA (Pennsylvania State University, University Park). American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 13 p. Navy-sponsored research. refs (AIAA PAPER 85-1624)

A space-marching method which describes mildly elliptic flows and includes a Poisson equation for the pressure distribution is presented for modeling incompressible separated flows. Momentum and continuity equations are treated as a coupled system to obtain a divergence-free velocity field. Once the Poisson equation is solved, it remains unchanged through subsequent iterations. Comparisons of the model predictions with data gathered from an unseparated turbulent flow in a cascade and a laminar separated flow in a suddenly expanding channel yield a favorable match. Although the model also successfully describes the flow past a cascade of cambered, double circular arc airfoils, applications are limited to conditions of only mild viscous/inviscid interaction.

M.S.K.

### A85-40778\*# Air Force Armament Lab., Eglin AFB, Fla.

#### THREE-DIMENSIONAL UNSTEADY EULER EQUATIONS SOLUTIONS ON DYNAMIC GRIDS

D. M. BELK (USAF, Armament Laboratory, Eglin AFB, FL), J. M. JANUS (U.S. Naval Coastal Systems Center, Panama City, FL), and D. L. WHITFIELD (Mississippi State University, Mississippi State) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 10 p. refs (Contract F08635-82-K-0409; NAG1-226) (AIAA PAPER 85-1704)

A method is presented for solving the three-dimensional unsteady Euler equations on dynamic grids based on flux vector splitting. The equations are cast in curvilinear coordinates and a finite volume discretization is used for handling arbitrary geometries. The discretized equations are solved using an explicit upwind second-order predictor corrector scheme that is stable for a CFL of 2. Characteristic variable boundary conditions are developed and used for unsteady impermeable surfaces and for the far-field boundary. Dynamic-grid results are presented for an oscillating air-foil and for a store separating from a reflection plate. For the cases considered of stores separating from a reflection plate, the unsteady aerodynamic forces on the store are significantly different from forces obtained by steady-state aerodynamics with the body inclination angle changed to account for plunge velocity. Author

### A85-40785\*#

#### IMPLICIT/EXPLICIT ANALYSIS OF INTERACTIVE PHENOMENA IN: SUPERSONIC, CHEMICALLY-REACTING, MIXING AND BOUNDARY LAYER PROBLEMS

S. M. DASH, N. SINHA, and B. J. YORK (Science Applications International Corp., Propulsion Gas Dynamics Div., Princeton, NJ) American Institute of Aeronautics and Astronautics, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 20 p. refs (Contract NAS1-16535; N00167-84-C-0061; DAAH01-84-C-0326) (AIAA PAPER 85-1717)

An efficient implicit/explicit procedure for solving the parabolized Navier-Stokes (PNS) equations to analyze supersonic, viscous, chemically-reacting flows is presented. The approach combines a fully-implicit algorithm for solving the parabolic mixing/boundary layer equations with an explicit algorithm for determining the hyperbolic pressure field. The unified model, SPLITP, contains provisions for treating bounding/embedded subsonic regions using

a pressure-splitting procedure which suppresses elliptic (upstream influence) effects without recourse to sublayer approximations. Several two-equation turbulence models with compressibility and curvature-correction terms are incorporated into SPLITP. Applications to a variety of flow problems are presented which include: ducted supersonic mixing and combustion flowfields, free jets and plumes, and, curved boundary layers and wall jets.

Author

### A85-40818#

#### PREDICTION OF THE REYNOLDS STRESS IN A COMPRESSOR PASSAGE

Y. OBIKANE (Best Software Co., Ltd., Kawasaki, Japan) AIAA, SAE, ASME, and ASCE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 8 p. refs (AIAA PAPER 85-1197)

A prediction method for a deformed-turbulent wake flow is proposed, and a second order turbulence model is proposed for the compressible flows. The passage flow through a stator passage is superposed by the mean flow computed by the implicit MacCormack method and a wake velocity deficit function. First, the streamlines are calculated from the mean flow computation; then, along the streamlines, the second order turbulence modeling equation is solved numerically. The predictions agree qualitatively with experimental results. The perturbation method to predict the complex flows is quite practical and may be extended to more complex aerodynamic design.

Author

### A85-40926

#### COMPUTATIONAL FLUID DYNAMICS CONFERENCE, 7TH, CINCINNATI, OH, JULY 15-17, 1985, TECHNICAL PAPERS

Conference sponsored by AIAA. New York, AIAA, 1985, 464 p. For individual items see A85-40927 to A85-40966.

Among the topics discussed are a novel three-dimensional vortex method, unsteady viscous flow around circular cylinders and airfoils, a time-accurate multiple grid algorithm, the numerical solution of incompressible flows by a marching multigrid nonlinear method, the Navier-Stokes solution for hypersonic flow over an indented nosetip, graphics and flow visualization in computational fluid dynamics, and a Navier-Stokes solution for the flow around a complete aircraft. Also covered are implicit schemes for hyperbolic conservation laws in curvilinear coordinates, an incremental multigrid strategy for fluid dynamic equations, numerical flow simulation by means of zonal grids, overset grids in compressible flow, noniterative parabolic grid generation for parabolized equations, FEM for high speed flows, and finite element approaches for aerothermal load prediction.

O.C.

### A85-40929\*# Cincinnati Univ., Ohio.

#### AN IMPLICIT TIME-MARCHING METHOD FOR STUDYING UNSTEADY FLOW WITH MASSIVE SEPARATION

G. A. OSSWALD, K. N. GHIA, and U. CHIA (Cincinnati, University, OH) IN: Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers. New York, AIAA, 1985, p. 25-37. refs

(Contract AF-AFOSR-80-0610; NAG1-465)

(AIAA PAPER 85-1489)

A fully implicit time-marching method is developed such that all spatial derivatives are approximated using central differences, but no use is made of any artificial dissipation. The numerical method solves the discretized equations using Alternating Direction Implicit-Block Gaussian Elimination technique. The method is implemented in the unsteady analysis, which solves the incompressible Navier-Stokes equations in terms of vorticity and stream function in generalized orthogonal coordinates. A clustered conformal C-grid is employed, and every effort is made to resolve the various length scales in the flow problem. The metric discontinuity at the branch-cut is treated appropriately using analytic continuation. Introduction of the BGE reordering permits implicit treatment of the branch cut in the numerical method. The vorticity singularity at the cusped trailing edge is also appropriately treated. This accurate and efficient implicit method is used to study flow

at  $Re = 1000$ , past a 12-percent thick symmetric Joukowski airfoil at high angle of attack 30 and 53 deg. Author

#### A85-40936#

##### ANALYSIS OF THREE-DIMENSIONAL SEPARATED FLOW WITH THE BOUNDARY-LAYER EQUATIONS

D. E. EDWARDS and J. E. CARTER (United Technologies Research Center, East Hartford, CT) IN: Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers. New York, AIAA, 1985, p. 99-107. refs (Contract N00014-81-C-0381) (AIAA PAPER 85-1499)

An analysis based on the boundary-layer equations is presented for the prediction of three-dimensional separated flow. In this analysis, the boundary-layer equations are solved with finite difference techniques in four inverse (pressure is unknown) modes. One inverse mode, in which the component of vorticity normal to the surface is specified at the boundary-layer edge, is shown to result in an elliptic system of boundary-layer equations which has departure solutions when solved with a forward marching technique. The accuracy of the present analysis in the other three inverse modes using forward marching techniques is demonstrated for: (1) separated flow over an infinite swept wing which has been rendered three dimensional with a rotated coordinate system; and (2) a three-dimensional separated flow problem analyzed by Smith. The principal conclusion of this paper is that the methodology is now in place to solve the boundary-layer equations for three-dimensional separated flow and hence work should now be focused on the development of three-dimensional viscous-inviscid interaction procedures. Author

#### A85-40939#

##### IMPLICIT BOUNDARY TREATMENT FOR JOINED AND DISJOINT PATCHED MESH SYSTEMS

C. K. LOMBARD and E. VENKATAPATHY (Peda Corp., Palo Alto, CA) IN: Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers. New York, AIAA, 1985, p. 129-140. refs (Contract F49620-83-C-0084) (AIAA PAPER 85-1503)

The flux difference eigenvector split upwind scheme for the compressible Euler or Navier-Stokes equation designated 'CSCM' is applied with suitable adaptation to the problem of capturing embedded flow structures with aligned overset mesh systems. It is suggested that explicit-implicit difference relations with diagonally dominant approximate factorization are appropriate for data exchange in the vicinity of interior patch boundaries. Alternative stable implicit boundary procedures with sequential solving of the meshes are explored in the context of a quasi-two-dimensional viscous pipe flow problem. O.C.

#### A85-40963\*# University Coll. of Swansea (Wales).

##### FINITE ELEMENT METHODS FOR HIGH SPEED FLOWS

R. LOEHNER, K. MORGAN, J. PERAIRE, and O. C. ZIENKIEWICZ (Swansea, University College, Wales) IN: Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers. New York, AIAA, 1985, p. 403-410. Research supported by the Ministerio de Educacion y Ciencia. refs (Contract NAGW-478) (AIAA PAPER 85-1533)

An explicit finite element based solution procedure for solving the equations of compressible viscous high speed flow is presented. The method uses domain splitting to advance the solution with different timesteps on different portions of the mesh. For steady inviscid flows, adaptive mesh refinement procedures are successfully employed to enhance the definition of discontinuities. Preliminary ideas on the application of adaptive mesh refinement to the solution of problems involving steady viscous flow are presented. Sample timings are given for the performance of the finite element code on modern supercomputers. Author

#### A85-40985#

##### DYNAMIC CHARACTERISTICS OF PERIPHERAL JET ACV. I - HEAVING MOTION

T. MORI and H. MAEDA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 364, 1984, p. 293-301. In Japanese, with abstract in English. refs

The theory of the dynamics of peripheral jet ACV is presented. The flow patterns under the bottom of the ACV are classified into two types, i.e. underfed and overfed regimes. The mathematical models associated with such regimes are presented and the equations of those models are derived. The forced heaving oscillation of a two-dimensional ACV model is investigated experimentally and variations of cushion pressure and lift force are measured and compared with the results obtained by the numerical calculation. The coincidence of these two results seems to be reasonable. The heaving motion of ACV which is induced by the simple harmonic oscillation of the ground board is also analyzed numerically. Author

#### A85-40989#

##### UNSTEADY, SEPARATED FLOW

K. OSHIMA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 365, 1984, p. 330-335. In Japanese. refs

Effects of vorticity on the flow separation and vortical flow are characterized and illustrated with drawings and diagrams. Unsteady flow around two-dimensional wings, the trailing vortex dependence on vorticity, and flow with a movable separation point are defined. Unsteady three-dimensional flow separation and two-dimensional flow separation are compared. Characteristics of flow having infinite Reynolds number are discussed. S.H.

#### A85-40991#

##### CATEGORIES AND CALCULATIONS OF THREE-DIMENSIONAL BOUNDARY-LAYER-SEPARATION

N. NISHIKAWA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 365, 1984, p. 341-351. In Japanese. refs

The three-dimensional boundary layer separation is characterized and its numerical calculation is discussed. The three-dimensional boundary layer separation is defined according to envelope and skin friction line theories. Flow separations behind the hatch-back car, are analyzed and applications of nose-coordinate to a parabolic body, use of the ZIG-ZAG scheme, and evaluation of the characteristic box scheme are studied. S.H.

#### A85-41001#

##### DYNAMIC CHARACTERISTICS OF PERIPHERAL JET ACV. II - PITCHING MOTION

T. MORI and H. MAEDA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 366, 1984, p. 415-421. In Japanese, with abstract in English. refs

The dynamic pitching characteristics of peripheral jet ACV (Air Cushion Vehicle) which have a stability curtain are investigated analytically and experimentally. The measured values of moment, lift and cushion pressure are compared with numerical results noting applicability to the pitching motion. The response of ACV to the sinusoidal pitching oscillation of the ground is also studied. Author

#### A85-41006#

##### DYNAMIC CHARACTERISTICS OF PERIPHERAL JET ACV. III - COUPLING MOTION OF HEAVING AND PITCHING

T. MORI and H. MAEDA Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 367, 1984, p. 469-476. In Japanese, with abstract in English. refs

The paper presents the dynamic characteristics of peripheral jet ACV (Air Cushion Vehicle) which has two degrees of freedom, i.e., heaving and pitching motion. The experiments are carried out for an ACV model, noting that the experimental results agree considerably with the analytical values. Furthermore, the response



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characteristics of ACV induced by the ground board oscillations of various modes are also investigated. Author

**A85-41032#**

### **TECHNIQUES FOR MEASUREMENT OF STRAIN AND TEMPERATURE IN ADVANCED ENGINE DEVELOPMENT**

K. JIMBO Japan Society for Aeronautical and Space Sciences, Journal (ISSN 0021-4663), vol. 32, no. 371, 1984, p. 715-724. In Japanese. refs

Techniques for measurement of strain and temperature in aircraft engines are described. Strain measurements discussed include strain gage, frequency modulation grid, optical, thin film gage, thermoelastic stress analysis, double core fiber optics strain sensor, and thin film capacitive strain sensor systems. Characteristics of double spectral area pyrometers, IR photograph systems, thin film thermocouples, and fiber optic temperature sensor systems are analyzed. Laser holography for measuring engine blade vibration is included. S.H.

**A85-41121**

### **STRESS ANALYSIS OF A SPF/DB COMPOSITE SANDWICH PANEL**

T. D. KIM and C. E. S. UENG (Georgia Institute of Technology, Atlanta) (George Washington University and NASA, Symposium on Advances and Trends in Structures and Dynamics, Washington, DC, Oct. 22-25, 1984) Computers and Structures (ISSN 0045-7949), vol. 20, no. 1-3, 1985, p. 365-374. refs

The process of superplastic forming with diffusion bonding is first introduced. The stress analysis of a bending problem of a SPF/DB sandwich panel consisting of four projections and subjected to a concentrated load at the middle is carried out by a FEM method where triangular elements are used. Principal stresses and maximum shear stresses in a projection wall are presented. Attention is focused on the general understanding of the overall effect due to a load on the stress distribution over the projection walls in a sandwich core. Author

**A85-41418#**

### **LIFE PREDICTION METHODOLOGY FOR AIRCRAFT GAS TURBINE ENGINE DISKS**

R. MAHORTER, G. LONDON, S. FOWLER (U.S. Navy, Naval Air Development Center, Warminster, PA), and J. SALVINO (U.S. Navy, Naval Air Propulsion Center, Trenton, NJ) AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 7 p. (AIAA PAPER 85-1141)

The paper discusses the use of cyclic spin pit testing of gas turbine disks as a means of predicting the B.1 life (one failure in one thousand parts). The life predictions are made using statistical analysis of a limited number of tests. The predictions are compared to analytical predictions made by the manufacturer. It was concluded that analytical predictions can be non-conservative. Author

**A85-41425#**

### **A PROPOSED METHOD FOR REMOTE THERMOMETRY IN TURBINE ENGINES**

B. W. NOEL (Los Alamos National Laboratory, NM), H. M. BORELLA, L. A. FRANKS, B. R. MARSHALL (EG&G Energy Measurements, Inc., Goleta, CA), S. W. ALLISON (Oak Ridge Gaseous Diffusion Plant, TN) et al. AIAA, SAE, ASME, and ASEE, Joint Propulsion Conference, 21st, Monterey, CA, July 8-10, 1985. 7 p. USAF-supported research. refs (AIAA PAPER 85-1468)

A new technique for remote thermometry using laser-induced fluorescence of thermographic phosphors may be adaptable to temperature measurements on rotating and stationary components of operating turbine engines. Initial experiments to determine the temperature range of the phosphors and to explore methods of bonding the phosphors to the engine components are described. Author

**A85-41547**

### **ELECTRONIC WARFARE - THE NEXT 15 YEARS**

T. G. QUIRK (Westinghouse Electric Corp., Defense Group, Baltimore, MD) Defense Electronics (ISSN 0278-3479), vol. 17, July 1985, p. 86, 88.

On the basis of current trends, it is projected that the EW systems available by the year 2000, including avionics, will be distinguished by their compatibility with stealthy vehicular platforms, high adaptability to combat scenarios, vehicle-conformal containers, and multifunction characteristics. Transmitters and receivers will perhaps be contained within a single IC, and AI techniques may be able to yield such capabilities as instantaneous signal digitalization. Fusion of electronic units will allow a single system to accommodate navigation, identification, communications, countermeasures, and fire control functions. VHSIC and GaAs electronics appear to be the two most fundamental technological bases for the aforementioned developments. The adaptive response of these systems is noted to radically depend on the pace of software development. O.C.

**A85-41784**

### **COOLING CHARACTERISTICS OF AIR COOLED RADIAL TURBINE BLADES**

T. SATO, K. TAKEISHI, M. MATSUURA (Mitsubishi Heavy Industries Co., Ltd., Takasago Technical Institute, Japan), and J. MIYAUCHI (Mitsubishi Motors Corp., Truck and Bus Engineering Center, Tokyo, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 1. Tokyo, Gas Turbine Society of Japan, 1984, p. 59-66. refs

The cooling design and the cooling characteristics of air cooled radial turbine wheels, which are designed for use with the gas generator turbine for the 400 horse power truck gas turbine engine, are presented. A high temperature and high speed test was performed under aerodynamically similar conditions to that of the prototype engine in order to confirm the metal temperature of the newly developed integrated casting wheels constructed of the superalloys INCO 713C. The test results compared with the analytical value, which was established on the basis of the results of the heat transfer test and the water flow test, are discussed. Author

**A85-41791**

### **RESEARCH AND DEVELOPMENT ON COMBUSTORS FOR ADVANCED REHEAT GAS TURBINE**

K. MORI, J. KITAJIMA, T. KIMURA (Kawasaki Heavy Industries, Ltd., Technical Institute, Akashi, Japan), and Y. ENZAKI (Engineering Research Association for Advanced Gas Turbines, Tokyo, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 1. Tokyo, Gas Turbine Society of Japan, 1984, p. 159-166. Research sponsored by the Agency of Industrial Science and Technology and Engineering Research, Association for Advanced Gas Turbines. refs

An outline of the research and development on the combustors for the advanced reheat gas turbine is presented. According to the R & D program, the original combustors - the high pressure combustor and the reheat combustor - have been developed along the planned schedule and are ready for operation at the factory. R & D tests such as the flow visualization test, the near atmospheric pressure combustion test and the pressurized combustion test are stated. Author

**A85-41793**

### **THERMAL CHARACTERISTICS OF GAS TURBINE COMBUSTOR IN HIGH TEMPERATURE OPERATION**

S. ACHIWA, M. SASAKI, and S. YAMAZAKI (Nissan Motor Co., Ltd., Central Engineering Laboratories, Yokosuka, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 1. Tokyo, Gas Turbine Society of Japan, 1984, p. 175-179.

Attention is given to the development status of a silicon carbide gas turbine can-type combustor of 2 mm material cross section and 85 mm diameter, for which thermal resistance and thermal

cycle tests have been conducted under conditions of 900 °C air inlet temperature and an outlet gas temperature of 1350 °C. It has been determined that sharp temperature gradients generated by carbon deposits must be eliminated through careful design; the fuels that may be used, while various, must also be such as to generate minimum carbon deposits. O.C.

#### A85-41800

##### EFFECTS OF HETEROGENEITY OF MIXTURES ON GASEOUS EMISSIONS IN PREMIXED/PREVAPORIZED COMBUSTION

S. HAYASHI (National Aerospace Laboratory, Chofu, Japan), N. HORIE (Suzuki Motor Co., Ltd., Kami, Japan), and T. GOSHIMA (Sharp Precision Machinery Co., Ltd., Osaka, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 1. Tokyo, Gas Turbine Society of Japan, 1984, p. 245-251. refs

A quasi-one-dimensional flame tube is used to evaluate the effects of experimental parameters on the emissions of NO(x), CO and HC from a 'premixed/prevaporized' combustor. Experiments have been conducted using the iso-octane over a wide range of equivalence ratio for inlet air temperatures of 450, 550 and 650 K. An increase of homogeneity by improving prevaporization of the atomized fuel results in a drastic reduction of NO(x) emission and in appreciable decrease of CO and HC emissions at fuel-lean conditions. A correlation of emission index for NO(x) at complete fuel prevaporization with adiabatic flame temperature is presented. Author

#### A85-41821

##### A CONSIDERATION CONCERNING STALL AND SURGE LIMITATIONS WITHIN CENTRIFUGAL COMPRESSORS. II

E. EJIRI, H. KOSUGE, and T. ITOH (Nissan Motor Co., Ltd., Engine Research Laboratory, Yokosuka, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 479-485. refs

The relative velocity reduction between the inlet and throat of the inducer, and between the inlet and exit of the impeller was examined with respect to the inducer throat Mach number at the critical condition of surge within centrifugal compressors. A one-dimensional-flow analysis within the impeller was applied to the experimental data on four types of impellers obtained in a 'diffuserless' test rig. The analysis shows the relative velocity reduction between the inlet and exit of the impeller is a predominant parameter in determining 'impeller surge', whereas the relative velocity reduction between the inlet and exit of the impeller and the inducer throat Mach number are the governing parameters in determining 'inducer surge'. The relative velocity reduction between the inlet and throat of the inducer is constant in 'inducer surge' region for each impeller. Author

#### A85-41823

##### SLIP FACTOR DEPENDENCE ON FLOW COEFFICIENT IN CENTRIFUGAL COMPRESSORS

Y. SAKAMOTO, M. SUYARI, A. NAGATA (Kobe Steel, Ltd., Japan), T. KOBAYASHI, H. ISHIGAMI (Kobe Steel, Ltd., Takasago, Japan) et al. IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 495-500. refs

Slip Factor dependence on flow coefficient was investigated experimentally using a new technique to estimate the mean flow velocity at a vaneless diffuser. The characteristics of Slip Factor dependence on flow coefficient were found to change depending on whether the centrifugal compressors went into choking condition or not in the normal operation range. It was found that the vaneless diffuser had some influences on the internal flow of the impeller; due to the facts that the inducer went into choking condition at different rotor speeds, and that the blockage factor on the inducer choke initiation were also different for the different blade angles of the vaneless diffuser. The vaneless diffuser was found also to have some influences on the internal flow of the impeller exit region, at the compressor operation point near surge. But the

influence of the diffusers on Slip Factor seemed to be only little, as far as the data was concerned. Author

#### A85-41830

##### THE INFLUENCE OF AIRCRAFT TURBOMACHINE TECHNOLOGY ON VEHICULAR TURBOCHARGER DESIGN

J. L. MASON (Garrett Corp., Los Angeles, CA) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 547-554. refs

A number of categories of aircraft turbomachinery have influenced vehicular turbocharger design. This paper deals with the interrelationship between the technology of aircraft turbomachinery and that of turbochargers for applications such as trucks, off-highway vehicles, passenger cars, and small piston-engine aircraft. Historically, many turbocharger design features, aerodynamic and mechanical, were first introduced and proved out in aircraft machinery. Today, some features recently introduced in aircraft turbomachinery appear potentially applicable to vehicular turbochargers, provided of course that they are not too costly to incorporate. This paper covers in sequence the following topics: compressors, turbines, bearings, materials, and controls. Author

#### A85-41831

##### DEVELOPMENT OF HIGH SPECIFIC SPEED CENTRIFUGAL COMPRESSORS FOR TURBOCHARGERS

M. SAITO, M. KURASAWA, K. KURATA, Y. MORISHITA, Y. IMAI (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) et al. IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 555-560. refs

Advanced high-performance centrifugal compressors have been developed using the latest numerical methods and experimental techniques, including two-focus laser velocimetry. The general design of two such compressors with impeller diameters of 92 and 30 mm, specific speeds of 0.21 and 0.20, and efficiencies of 0.80 and 0.72, respectively, is presented together with some test results. The compressors described here have been successfully used in small high-performance turbocharges. V.L.

#### A85-41832

##### DEVELOPMENT OF A HIGH SPECIFIC SPEED RADIAL-INFLOW TURBINE FOR TURBOCHARGERS

T. OHKUWA, T. KOIKE, M. SAKAKIDA, N. MISAKI, K. FUNAYAMA (Ishikawajima-Harima Heavy Industries Co., Ltd., Tokyo, Japan) et al. IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 561-566. refs

The development of an advanced radial-inflow turbine with a high specific speed for turbocharged vehicle engine applications is discussed. In particular, attention is given to the design and principal characteristics of the impeller, scroll, and exhaust diffuser of the turbine and to the results of strength analysis. The flow capacity of the advanced model exceeds that of conventional turbines by more than 80 percent; the efficiency of the turbine is 82 percent at a specific speed of 0.228. V.L.

#### A85-41833

##### INFLUENCE OF HEAT TRANSFER BETWEEN TURBINE AND COMPRESSOR ON THE PERFORMANCE OF SMALL TURBOCHARGERS

M. RAUTENBERG, M. MALOBABIC (Hannover, Universitaet, Hannover, West Germany), and A. MOBARAK (Cairo University, Egypt) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 2. Tokyo, Gas Turbine Society of Japan, 1984, p. 567-574. refs

When operating a turbocharger with an engine the turbine transfers a considerable amount of heat to its environment and to the compressor. Therefore the flow processes in the turbine as well as in the compressor are strongly diabatic. The definition and the experimental determination of turbine and compressor efficiency require a clear distinction between adiabatic and diabatic

## 12 ENGINEERING

efficiencies since the heat flux between turbine and compressor must be taken into account. The influence of the heat flux between turbine and compressor on the compression process was studied at two turbochargers for passenger cars of different design. The essential difference of the two turbochargers is the arrangement of turbine and compressor, because the type of bearing is different for each charger. While one turbocharger has sliding bearings, the other charger exhibits roller bearings. The experiments were performed with hot and cold operation of the chargers. The results of the measurements show that the heat flux transferred from the turbine to the compressor and thus the compressor exit temperature depends to a large extent on the mechanical design of the turbocharger. Author

**A85-41838**

### **DOE AUTOMOTIVE GAS TURBINE MODERN TECHNOLOGY ENGINE PROGRAM**

S. B. KRAMER (DOE, Washington, DC) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 3. Tokyo, Gas Turbine Society of Japan, 1984, p. 667-674. refs

A development history and current development status assessment is presented for the U.S. Department of Energy's automotive gas turbine program, with attention to the proof-of-concept schedules instituted and the progress made by research contractors toward these scheduled goals. Emphasis is given to performance gains theoretically projected for, and experimentally obtained with, novel ceramic components for the various test engines' high temperature sections. These techniques derive their value not only from the achievement of higher and more efficient operating temperatures, but in virtue of potential manufacturing cost reductions and reliability and service life improvements. Significant reductions in engine size and weight are noted for the vehicular gas turbines developed. O.C.

**A85-42015**

### **SCATTERING FROM A PERIODIC ARRAY OF CONDUCTING BARS OF FINITE SURFACE RESISTANCE**

B. J. RUBIN (IBM Corp., General Technology Div., Hopewell Junction, NY) and H. L. BERTONI (New York, Polytechnic Institute, Brooklyn) Radio Science (ISSN 0048-6604), vol. 20, July-Aug. 1985, p. 827-832. refs

The scattering of electromagnetic waves from a two-dimensional structure consisting of a periodic array of conducting bars of rectangular cross section is treated. The E mode case is considered, in which current essentially flows around each bar, perpendicular to the bar axis. Numerical solutions are obtained based on approximating the currents on each bar by a set of P 'triangle' functions. The electric field radiated by the periodic array of triangle current functions is found by standard Fourier series techniques. The field is required to satisfy the boundary conditions in an integral sense over P intervals associated with the triangle functions. The resulting P equations in P unknowns are solved numerically. Finally, a number of examples are analyzed, including transmission gratings and parallel plate polarizers. Author

**A85-42106**

### **MAIN STAGES AND PROBLEMS IN THE DESIGN OF LOW-GAIN ACTIVE ANTENNAS [OSNOVNYE ETAPY I ZADACHI PROEKTIROVANIYA SLABONAPRAVLENNYKH AKTIVNYKH ANTENN]**

A. A. SHCHERBINA Radiotekhnika (Kharkov) (ISSN 0485-8972), no. 59, 1984, p. 77-84. In Russian. refs

The paper examines the stages in the design of low-gain antenna amplifiers and antenna power amplifiers for use on flight vehicles and on the ground. An algorithm and program for the parametric synthesis of active antennas are developed whose application significantly speeds up the production of such devices. An example of the parametric synthesis of a small antenna amplifier is given. B.J.

**A85-42121**

### **NUMERICAL ANALYSIS OF TURBULENT FLOW PAST A PLATE USING EQUATIONS FOR FLUCTUATIONS [CHISLENNYI RASCHET TURBULENTNOGO OTEKANIIA PLASTINY S PRIMENENIEM URAVNENII DLIYA PUL'SATSII]**

K. B. DZHAKUPOV (Kazakhskii Gosudarstvennyi Universitet, Alma-Ata, Kazakh SSR) Akademiia Nauk SSSR, Sibirskoe Otdelenie, Izvestiia, Seria Tekhnicheskie Nauki (ISSN 0002-3434), March 1985, p. 61-67. In Russian. refs

A method for closing Reynolds equations for mean parameters using equations for fluctuations is proposed whereby the mean fluctuation parameters are expressed in terms of the corresponding instantaneous values. Numerical experiments are carried out for the case of isothermal flow of a viscous incompressible fluid past a plate of finite length at zero angle of attack. The fluctuations of the longitudinal velocity component and drag coefficient are plotted vs time; flow patterns and velocity distributions are also presented. V.L.

**A85-42564#**

### **AERO/HYDRODYNAMIC STABILITY OF ELASTICALLY SUPPORTED PLATES IN NARROW CHANNELS WITH UPSTREAM BARRIERS PREVENTING FLOW REDISTRIBUTION**

W. D. MARK (Bolt Beranek and Newman, Inc., Cambridge, MA) ASME, Transactions, Journal of Vibration, Acoustics, Stress, and Reliability in Design (ISSN 0739-3717), vol. 107, July 1985, p. 319-328. refs

The dynamic stability of an elastically supported finite rigid plate centered in a straight narrow channel with incompressible flow on both sides of the plate and an upstream barrier preventing flow redistribution is analyzed. An integral equation for the pressure in a narrow channel having arbitrary small time-dependent boundary displacements is formulated and solved for the pressure distribution in terms of the boundary motion. The resulting expression for the time-dependent pressure distribution is combined with the plate differential equations of motion to yield the homogeneous equations of motion of the plate-fluid autonomous system. The Lienard-Chipart stability criterion is applied to the coefficients of the plate-fluid system equations to yield necessary and sufficient conditions for the dynamic stability of the plate-fluid system. The resulting stability requirements are expressed as algebraic inequalities involving dimensionless plate-fluid system parameters. Author

**A85-42659**

### **HOLOGRAPHIC-INTERFEROMETRIC VIBRATION ANALYSIS FOR FAST-ROTATING CONSTRUCTIONAL UNITS [ZUR HOLOGRAFISCH-INTERFEROMETRISCHEN ANALYSE AN SCHNELLROTIERENDEN BAUTEILEN]**

M.-A. BEECK Hannover, Universitaet, Fakultae fuer Maschinenwesen, Dr.-Ing. Dissertation, 1984, 160 p. In German. refs

A systematic theoretical and experimental study of the effects of an object's angular motion on vibration interference patterns is presented and used to develop and test holographic measurement methods. These methods can be applied to determine the axial vibration behavior of rotating constructional units at high circumferential speeds and are suitable for practical application. The effects of objective motions on the interference patterns are examined and ways of suppressing the resulting pattern modulations are demonstrated. C.D.

**A85-42940#**

### **THE DETERMINATION OF LOAD AND SLOPE TRANSFORMATION MATRICES FOR AEROELASTIC ANALYSIS**

K. APPA, M. YANKULICH, and D. L. COWAN (Northrop Corp., Hawthorne, CA) Journal of Aircraft (ISSN 0021-8669), vol. 22, Aug. 1985, p. 734-736. refs

In structural and aerodynamic analyses of aircraft structures, there is a need to transform the load vectors from the aerodynamic set to the structural set of grid locations. The present method for the accomplishment of such transformations employs the piecewise

cubic monotone interpolation scheme of Fritsch and Carlson (1980) to determine the displacements and slopes at the aerodynamic control points derived from the columns of the flexibility matrix. This procedure offers greater accuracy than current alternatives.

O.C.

#### A85-43052#

##### A MEASURING AND COMPUTING OFF-LINE AND ON-LINE SYSTEM FOR A TURBINE LABORATORY

Z. LISEWSKI and J. MLYNARSKI Instytut Lotnictwa, Prace (ISSN 0509-6669), no. 99, 1984, p. 23-40. In Polish.

The development process and the present state of the instrumentation used in the Turbine Laboratory, Institute of Aeronautics, are described. Off-line and on-line systems for recording and processing the measurement data are discussed. The investigation process is presented in all its complexity, including some problems of modern measuring technique and computer systems for processing the results. The paper contains also a description of the entire processing cycle since the measurement of parameters on the test stand until the final results are obtained in a numerical and graphical form.

Author

#### A85-43154

##### MODERN PROCESSES FOR SUPERCLEAN METAL POWDER PRODUCTION

R. RUTHARDT (Leybold-Heraeus GmbH, Hanau, West Germany) IN: PM aerospace materials; Proceedings of the International Conference, Bern, Switzerland, November 12-14, 1984. Volume 2. Shrewsbury, England, MPR Publishing Services, Ltd., 1984, p. 4-1 to 4-10. refs

Attention is given to the impurity-reduction processing measures that must be taken in the course of titanium alloy and superalloy powder metallurgy materials in order to ensure that the full measure of performance and reliability advantages are obtained. The characteristic differences between metallic powders and their ceramic particle impurities are taken advantage of in purification operations, such as that conducted by electrostatic precipitators in rotational atomization. Induction drip melting, arc melting, and plasma melting are useful new techniques for melt purity retention. Of these, the high processing rates achievable by arc melting are noted to recommend this technique highly for industrial application, as well as large production batch capacity.

O.C.

#### A85-43158

##### SCREW PRESS FORGING OF POWDER HIP BILLET TO CRITICAL GAS TURBINE DISCS AND WHEELS

M. W. COCKELL and K. A. G. BOYCE (Doncasters Monk Bridge, Ltd., Leeds, England) IN: PM aerospace materials; Proceedings of the International Conference, Bern, Switzerland, November 12-14, 1984. Volume 2. Shrewsbury, England, MPR Publishing Services, Ltd., 1984, p. 15-0 to 15-12.

A low cost conventional forging method has been developed for producing critical gas turbine disks and wheels in powder hot isostatic press (HIP) billet. The method is controllable and repeatable, giving a technically acceptable product over a wide range of shapes. HIP billets in various alloys have been forged by this technique, and a range of end users are at present designing engines around the use of forged Nimonic AP1 disks. Typical shapes, structures and properties are presented and compared with other, more conventionally produced and used alloys. Also, a brief comparison is made between the more complex forging techniques and the present conventional forging method. Future trends in melting/casting technology for high volume fraction delta-prime containing alloys pose a threat to the powder manufacturers. Work on some of the alloys produced by these alternative methods shows them to be equally forgeable to powder HIP billet.

Author

#### A85-43232#

##### ON A GENERALIZED OPTIMALITY CRITERIA METHOD

R. XIA and P. LIU (Beijing Institute of Aeronautics and Astronautics, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 5, Dec. 1984, p. 406-415. In Chinese, with abstract in English. refs

A second order Taylor series expansion was used to reduce the problem of structural optimization to a sequence of numerical approximations. Iterative expressions of design variables and Lagrangian multipliers are derived based on the Kuhn-Tucker conditions. The method can be applied to optimality problems involving several different behavioral constraints as long as a second order Taylor expansion series can be generated. Several typical structures with stress and displacement constraints have been optimized to illustrate the effectiveness of the method. The results of the numerical computations show that the method is sufficiently accurate for most engineering applications and requires only two or three iterations.

I.H.

#### A85-43238#

##### DYNAMIC ANALYSIS OF ROTOR-BEARING SYSTEMS BY FINITE ELEMENT METHOD

Y. OU and P. LI (Nanhua Powerplant Research Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 5, Dec. 1984, p. 459-463. In Chinese, with abstract in English.

The finite element method is used to analyze dynamic problems of rotor-bearing systems. The system motion equations are presented in a fixed and a rotating coordinate system. Nelson's element is extended to considering transverse shear effects, which are of great importance for complicated aircraft engines. A Finite Element Program for Rotor-Bearing Systems (FEPRS) is presented for dynamic modelling of the rotor-bearing system which consists of rigid disks, distributed parameter finite rotor elements and discrete bearings. The whirl frequencies can be calculated for complicated rotor-bearing systems in various whirl states, and mode shapes can be automatically drawn by implementing this program on a computer. A lot of practical examples have been analyzed. The results are satisfactory in comparison with experimental data.

Author

N85-30180# Ohio Univ., Athens. Dept. of Electrical and Computer Engineering.

##### MEASUREMENT OF RF FIELDS ASSOCIATED WITH ISM EQUIPMENT AS IT RELATES TO AERONAUTICAL SERVICES Final Report

J. D. NICKUM and W. DRURY May 1985 187 p refs (Contract DTFA01-83-C-10007)

(FAA/ES-84-2; OU/AEC-EER-67-1) Avail: NTIS HC A09/MF A01

Described are the RF field measurements of four Industrial, Scientific and medical devices to characterize the fundamental and 4th harmonic radiation from these devices according to FCC Part 18 and CISPR Publication 11 and 11A. The effects of the 4th harmonic radiation is considered with respect to instrument landing systems (ILS) localizer receiver susceptibility. The testing was performed at an open field test site with measurements made on the ground and at elevation angles from 45 to 75 degrees. Additionally, an aircraft equipped with calibrated antennas was flown over the ISM device to determine the RF fields radiated overhead at the 4th harmonic of the fundamental operating frequency. Results indicate that RF fields (at ILS localizer frequencies) of 20 to harmonic emissions in the vicinity of ISM equipment.

Author

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**N85-30342\*#** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### **CORRELATION OF RHEOLOGICAL CHARACTERISTICS OF LUBRICANTS WITH TRANSMISSION EFFICIENCY MEASUREMENTS**

B. O. JACOBSON (Lulea Univ.), B. J. HAMROCK, and E. HOEGLUND (Lulea Univ.) 1985 15 p refs Presented at the Intern. Tribology Conf., Tokyo, 8-10 Jul. 1985; sponsored by Japan Society of Lubrication Engineers (NASA-TM-86988; E-2531; NAS 1.15:86988) Avail: NTIS HC A02/MF A01 CSCL 11H

The power efficiency of a helicopter transmission has been analyzed for 11 lubricants by looking at the Newtonian and non-Newtonian properties of the lubricants. A non-Newtonian property of the lubricants was the limiting shear strength proportionality constant. The tests were performed on a high-pressure, short-time shear strength analyzer. A power efficiency formula that was obtained by analyzing the Newtonian and non-Newtonian properties of the lubricants is presented in detail. B.W.

**N85-30343#** Department of the Navy, Washington, D. C.

### **LOW-PROFILE FASTENER Patent Application**

J. T. MCGLONE and R. L. MCGIBONEY, inventors (to Navy) 22 Feb. 1985 9 p (AD-D011667; US-PATENT-APPL-SN-704124) Avail: NTIS HC A02/MF A01 CSCL 13E

A low-profile fastener is described for securing parts such as swaybrace pads, mounting blocks and suspension loops onto exterior surfaces of multiple ejector racks in aircraft. The fastener consists of a retainer housing formed with an annular neck and a thin wrench head, and an insert threaded into the nut with internal threads. The fastener neck is inserted from within the rack through a mounting hole aligned with a hole of the part to be secured. A bolt inserted through the holes from the exposed side of the part is screwed into the insert and tightened to the desired torque. The thin wrench head is the only portion of the fastener protruding into the rack. Author (GRA)

**N85-30344#** Department of the Air Force, Washington, D.C.

### **VERY HIGH SPEED LAP WITH POSITIVE LIFT EFFECT Patent Application**

R. K. LEE, inventor (to Air Force) 8 Apr. 1985 15 p (AD-D011710; US-PATENT-APPL-SN-720937) Avail: NTIS HC A02/MF A01 CSCL 13I

This patent application discloses a rotary lapping system for grinding a workpiece in an abrasive slurry liquid and producing a positive lift in the abrasive slurry liquid. The positive lift is the result of the particular mounting of the grinding pads which causes the leading edge pads to possess a positive angle of attack during rotation in the abrasive slurry liquid. The advantages of a positive lift in the grinding pads includes preventing the grinding tools from digging into the surface of the workpiece during very high speed lap grinding. Trailing edge grinding pads are allowed to produce, in one embodiment, a negative angle of attack which results in a negative lift. The net lift of all grinding pads may be a neutral lift, which allows the entire lap substrate to be tilted and allow working of local areas while the leading edge guiding pads continue to hydroplane over the workpiece surface and avoid tendencies to dig into the surface. GRA

**N85-30345#** Department of the Air Force, Washington, D.C.

### **VERY HIGH SPEED LAP WITH NEGATIVE LIFT EFFECT Patent Application**

R. K. LEE, inventor (to Air Force) 8 Apr. 1985 15 p (AD-D011711; US-PATENT-APPL-SN-720936) Avail: NTIS HC A02/MF A01 CSCL 13I

This patent application discloses a rotary lapping system which contains a construction and mounting of grinding pads (called tesserae) which act to produce a negative lift or suction through hydrodynamic action with an abrasive slurry liquid. The rotary lapping system uses a plurality of negative lift tools, each of which is composed of a square base of metal, a rubber sheet bonded

to the base and four brass tessera bonded to the rubber sheet. Each tessera has a plurality of equally spaced, parallel grooves forming the grinding surface and the four tesserae are bonded to the rubber sheet to leave a relatively wide space, or slot, between each of the tessera. Four negative lift tools are attached around the outer edge of a metal ring, equally spaced, and the metal ring is bonded to a rubber ring which is bonded to the base of a power driven dish-like member for holding a grinding slurry to be fed to the grinding surfaces. The tessera construction causes a negative lift, or suction, to produce very strong cutting pressure with more rapid material removal without distortion of, or harm to the workpiece. The negative lift is the result of the particular mounting of the tesserae, which cause the tesserae at the leading edge of the rubber sheet to present a negative angle of attack to the abrasive slurry liquid during rotation. GRA

**N85-30354** Houston Univ., Tex.

### **ACROSSWIND RESPONSE OF TOWERS AND STACKS OF CIRCULAR CROSS-SECTION Ph.D. Thesis**

C. M. CHENG 1984 273 p Avail: Univ. Microfilms Order No. DA8428111

The wake induced acrosswind force and associated dynamic acrosswind behavior of circular cross-section structures were investigated. The experiments were conducted in a structural aerodynamics wind tunnel. The turbulent boundary layers, simulated by the combined action of an upstream barrier, spires, and floor roughness elements, were similar to the atmospheric boundary layers developed over typical open terrain and urban areas. The transcritical Reynolds number flow around circular cylinders was artificially simulated by placing two-dimensional surface roughness elements on the cylinder surface at optimal angular locations. The acrosswind response measurements were taken using a series of base pivoted aeroelastic models. Several analytical acrosswind response prediction models available in the literature were reviewed and the reliability of their predicted response was presented by comparing them with data available from full-scale measurements. Dissert Abstr.

**N85-30364\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### **SELECTED TOPICS IN EXPERIMENTAL AEROELASTICITY AT THE NASA LANGLEY RESEARCH CENTER**

R. H. RICKETTS Apr. 1985 15 p refs Presented at the 2d Intern. Symp. on Aeroelasticity and Struct. Dyn., Aachen, 1-3 Apr. 1985

(NASA-TM-86436; NAS 1.15:86436) Avail: NTIS HC A02/MF A01 CSCL 20K

The results of selected studies that have been conducted by the NASA Langley Research Center in the last three years are presented. The topics presented focus primarily on the ever-important transonic flight regime and include the following: body-freedom flutter of a forward-swept-wing configuration with and without relaxed static stability; instabilities associated with a new tilt-rotor vehicle; effects of winglets, supercritical airfoils, and spanwise curvature on wing flutter; wind-tunnel investigation of a flutter-like oscillation on a high-aspect-ratio flight research wing; results of wind-tunnel demonstration of the NASA decoupler pylon concept for passive suppression of wing/store flutter; and, new flutter testing methods which include testing at cryogenic temperatures for full scale Reynolds number simulation, subcritical response techniques for predicting onset of flutter, and a two-degree-of-freedom mount system for testing side-wall-mounted models. Author

**N85-30367\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**IMPACT DYNAMICS RESEARCH ON COMPOSITE TRANSPORT STRUCTURES**

H. D. CARDEN Mar. 1985 25 p refs Previously announced in IAA as N84-29975 (NASA-TM-86391; NAS 1.15:86391) Avail: NTIS HC A02/MF A01 CSCL 20K

The experimental and analytical efforts being undertaken to investigate the response of composite and aluminum structures under crash loading conditions were reviewed. A Boeing 720 airplane was used in the controlled-impact demonstration test. Energy absorption of composite materials, the tearing of fuselage skin panels, the friction and abrasion behavior of composite skins, and the crushing behavior and dynamic response of composite beams were among the topics addressed. R.S.F.

**N85-30376#** Dayton Univ., Ohio.

**HOLD-TIME EFFECTS IN ELEVATED TEMPERATURE FATIGUE CRACK PROPAGATION Interim Technical Report, Jan. 1983 - Jan. 1984**

T. WEERASOORIYA and T. NICHOLAS Wright-Patterson AFB, Ohio AFWAL Mar. 1985 32 p (Contract F33615-81-C-5015) (AD-A154146; AFWAL-TR-84-4184) Avail: NTIS HC A03/MF A01 CSCL 20K

An experimental investigation was conducted to evaluate the effects of hold-times on the fatigue crack growth rate of Inconel 718 to 649 C using compact tension specimens. Tests were run under computer controlled constant K conditions using compliance to determine crack length. Hold-times ranging from 5 to 50 s were applied at maximum, minimum, and intermediate load levels. The data show that hold-times at maximum load were the most damaging in terms of crack growth rate. Hold times greater than 5 s led to purely time-dependent crack growth behavior which was predictable from sustained load data using K as a correlating parameter. Hold-times at a minimum or intermediate load levels had little or no effect on crack growth rate. A linear cumulative damage model based solely on fatigue and sustained load data was found to be adequate for spectrum loading as long as the hold-times were at maximum load. Author (GRA)

**N85-31333#** Joint Publications Research Service, Arlington, Va. **WEST EUROPE REPORT: SCIENCE AND TECHNOLOGY** 5 Jul. 1985 90 p Transl. into ENGLISH from various West European articles (JPRS-WST-85-020) Avail: NTIS HC A05/MF A01

Various topics relating to scientific and technical research projects in Western Europe are discussed. Ceramics, biotechnology, civil aviation, industrial robots, crystal growth, fiber optics, and signal processing are among the topics considered.

**N85-31342** Ohio State Univ., Columbus.

**SIMULATION AND ANALYSIS OF AIRBORNE ANTENNA RADIATION PATTERNS Ph.D. Thesis**

J. J. G. KIM 1984 348 p Avail: Univ. Microfilms Order No. DA8504038

An accurate and efficient analytic solution for predicting high frequency radiation patterns of fuselage-mounted airborne antennas is described. This is an analytic study of airborne antenna patterns using the Uniform Geometrical Theory of Diffraction (UTD). The aircraft is modelled in its most basic form so that the solution is applicable to general-type aircraft. The fuselage is modelled as a perfectly conducting composite ellipsoid; whereas, the wings, stabilizers, nose, fuel tanks, and engines, etc., are simulated as perfectly conducting flat plates that can be attached to the fuselage and/or to each other. The composite-ellipsoid fuselage model is necessary to successfully simulate the wide variety of real world fuselage shapes. Since the antenna is mounted on the fuselage, it has a dominant effect on the resulting radiation pattern so it must be simulated accurately, especially near the antenna. Various radiation patterns are calculated for commercial, private, and military aircraft, and the space shuttle Orbiter. The application of

this solution to numerous practical airborne antenna problems illustrates its versatility and design capability. In most cases, the solution accuracy is verified by the comparisons between the calculated and measured data. Dissert. Abstr.

**N85-31349\*#** Boeing Commercial Airplane Co., Seattle, Wash. **STUDY TO DETERMINE POTENTIAL FLIGHT APPLICATIONS AND HUMAN FACTORS DESIGN GUIDELINES FOR VOICE RECOGNITION AND SYNTHESIS SYSTEMS Final Report**

R. W. WHITE and D. L. PARKS Jul. 1985 140 p refs (Contract NAS1-17367) (NASA-CR-172590; NAS 1.26:172590; D6-52528) Avail: NTIS HC A07/MF A01 CSCL 17B

A study was conducted to determine potential commercial aircraft flight deck applications and implementation guidelines for voice recognition and synthesis. At first, a survey of voice recognition and synthesis technology was undertaken to develop a working knowledge base. Then, numerous potential aircraft and simulator flight deck voice applications were identified and each proposed application was rated on a number of criteria in order to achieve an overall payoff rating. The potential voice recognition applications fell into five general categories: programming, interrogation, data entry, switch and mode selection, and continuous/time-critical action control. The ratings of the first three categories showed the most promise of being beneficial to flight deck operations. Possible applications of voice synthesis systems were categorized as automatic or pilot selectable and many were rated as being potentially beneficial. In addition, voice system implementation guidelines and pertinent performance criteria are proposed. Finally, the findings of this study are compared with those made in a recent NASA study of a 1995 transport concept. Author

**N85-31416#** National Aerospace Lab., Amsterdam (Netherlands). Informatics Div.

**INFORMATICS DIVISION**

1985 15 p refs Original contains color illustrations Avail: NTIS HC A02/MF A01

The activities of the Dutch National Aerospace Laboratory Informatics Division are outlined. These include research in electronics, applied mathematics, computer programming, and data operations. Ground systems in support of aircraft and spacecraft operations; computer aided research and development systems; and avionics are studied. Author (ESA)

**N85-31424** Drexel Univ., Philadelphia, Pa.

**THE EFFECT OF INJECTION-STREAM TURBULENCE ON FILM COOLING EFFECTIVENESS AND HEAT TRANSFER COEFFICIENTS Ph.D. Thesis**

S. J. CHEN 1985 286 p Avail: Univ. Microfilms Order No. DA8507467

Experiments were performed to investigate the effect of the injection stream turbulence on the film cooling process downstream of a two-dimensional film cooling slot. Results indicate that increases in the injection-stream turbulence intensities not only decrease the adiabatic film cooling effectiveness, but also increase the heat transfer coefficients; both effects reduce the film cooling performance in the mixing region. Dissert. Abstr.

**N85-31428** Iowa State Univ. of Science and Technology, Ames. **VORTEX SHEET MODELING WITH HIGHER ORDER CURVED PANELS Ph.D. Thesis**

M. G. NAGATI 1984 115 p Avail: Univ. Microfilms Order No. DA8505852

A method to predict the shape of the vortex sheet in the vicinity of its generating lifting surface is presented. The method uses potential flow vortex panels with a bilinear vorticity distribution and bicubic position interpolant to enable continuity to the necessary order. Positions of the panel nodes of successive streamwise stations are iteratively updated using the induced velocities computed from the sheet's configuration during the previous cycle. Complex wing loadings can be used, such as the case of deployed partial span flaps, or stalled conditions. However,

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the spanwise node density must be adjusted accordingly. Good correlation was obtained for a simply loaded wing tested in the Boeing Company Research Wind Tunnel, and the results show a considerable improvement over current methods of prediction which use discrete vortex filaments. Such a method would be useful in predicting certain stability derivatives in various flight regimes, as well as in the evaluation of the induced effects on other aircraft surfaces. Dissert. Abstr.

**N85-31438\*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### FLAT-PLATE TRANSITION

B. A. ERCEGOVIC *In its Transition in Turbines* p 61-68 Jul. 1985

Avail: NTIS HC A10/MF A01 CSCL 20D

A new research effort was undertaken to build a boundary-layer transition tunnel. This facility only recently became operational. The data obtained so far are merely qualitative. The main goal is to predict heat transfer given any combination of factors such as pressure gradient, turbulence level, Reynolds number, or intermittency factor. The boundary-layer transition tunnel is a closed-loop tunnel that controls the turbulence level, velocity and temperature of the air within it. Problems associated with the operation of this tunnel are examined. B.W.

**N85-31440\*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### A REVIEW AND ANALYSIS OF BOUNDARY LAYER TRANSITION DATA FOR TURBINE APPLICATION

R. E. GAUGLER *In its Transition in Turbines* p 81-93 Jul. 1985 refs Previously announced as N85-10306

Avail: NTIS HC A10/MF A01 CSCL 20D

A number of data sets from the open literature that include heat transfer data in apparently transitional boundary layers, with particular application to the turbine environment, were reviewed and analyzed to extract transition information. The data were analyzed by using a version of the STAN5 two-dimensional boundary layer code. The transition starting and ending points were determined by adjusting parameters in STAN5 until the calculations matched the data. The results are presented as a table of the deduced transition location and length as functions of the test parameters. The data sets reviewed cover a wide range of flow conditions, from low-speed, flat-plate tests to full-scale turbine airfoils operating at simulated turbine engine conditions. The results indicate that free-stream turbulence and pressure gradient have strong, and opposite, effects on the location of the start of transition and on the length of the transition zone.

Author

**N85-31444\*** National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

### HEAT TRANSFER IN AEROPROPULSION SYSTEMS

R. J. SIMONEAU 1985 37 p refs To be presented at the 1985 US-Japan Heat Transfer Joint Seminar, San Diego, Calif., 17-20 Sep. 1985; sponsored in part by NSF and Japan Society for the Promotion of Science

(NASA-TM-87066; E-2634; NAS 1.15:87066) Avail: NTIS HC A03/MF A01 CSCL 20D

Aeropropulsion heat transfer is reviewed. A research methodology based on a growing synergism between computations and experiments is examined. The aeropropulsion heat transfer arena is identified as high Reynolds number forced convection in a highly disturbed environment subject to strong gradients, body forces, abrupt geometry changes and high three dimensionality - all in an unsteady flow field. Numerous examples based on heat transfer to the aircraft gas turbine blade are presented to illustrate the types of heat transfer problems which are generic to aeropropulsion systems. The research focus of the near future in aeropropulsion heat transfer is projected. E.A.K.

**N85-31450\*** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

### A NEW FINITE ELEMENT APPROACH: PROGRESS IN INVISCID FLOW COMPUTATIONS

K. S. BEY, E. A. THORNTON (Old Dominion Univ.), P. DECHAUMPHAI (Old Dominion Univ.), and R. RAMAKRISHNAN (Old Dominion Univ.) Jul. 1985 16 p refs Presented at the AIAA 7th Computational Fluid Dyn. Conf., Cincinnati, 15-17 Jul. 1985

(NASA-TM-86434; NAS 1.15:86434; AIAA-PAPER-85-1533-CP)

Avail: NTIS HC A02/MF A01 CSCL 20D

Recent progress in the development of finite element methodology for the prediction of aerothermal loads is described. Two dimensional, inviscid computations are presented, but emphasis is placed on development of an approach extendable to three dimensional viscous flows. Research progress is described for: (1) utilization of a commercially available program to construct flow solution domains and display computational results, (2) development of an explicit Taylor-Galerkin solution algorithm, (3) closed form evaluation of finite element matrices, (4) vector computer programming strategies, and (5) validation of solutions. Two test problems of interest to NASA Langley aerothermal research are studied. Comparisons of finite element solutions for Mach 6 flow with other solution methods and experimental data validate fundamental capabilities of the approach for analyzing high speed inviscid compressible flows. Author

**N85-31471\*** European Space Agency, Paris (France).

### ON THE EVALUATION OF BOUNDARY LAYER MEASUREMENTS ON BOATTAILED BODIES OF REVOLUTION IN AXISYMMETRIC COMPRESSIBLE SUBSONIC FLOW

H. RIEDEL Dec. 1984 271 p refs Transl. into ENGLISH of "Zur Auswertung von Grenzschichtmessungen an achsensymmetrisch angestromten Drehkoerpern mit Heckverjuengung im Kompressiblen Unterschall" Brunswick, Rept. DFVLR-FB-84-09, 1984 Original language doc. previously announced as N84-28010

(ESA-TT-883; DFVLR-FB-84-09) Avail: NTIS HC A12/MF A01; original German version available from DFVLR, Cologne-DM 56.50

Turbulent boundary layer measurements of the boattailed afterbodies of a single jet body of revolution are considered. An axisymmetric flow for Mach numbers 0.50 and 0.96 and for corresponding Reynolds numbers 860,000 and 1.96 million was employed. Only the jet-off flow case was considered. The reference flow (potential flow) required for the boundary layer evaluation can be derived from the real viscous flow without recourse to potential flow computational methods. Author (ESA)

**N85-31515\*** Societe Nationale Industrielle Aerospatiale, Marignane (France). Helicopter Div.

### APPLICATION OF FINITE ELEMENT METHOD TO THE SIZING OF MECHANICAL PARTS

P. SARLIN 1984 17 p Presented at 10th European Rotorcraft Forum, The Hague, 28-31 Aug. 1984

(SNIAS-851-210-105) Avail: NTIS HC A02/MF A01

A finite element method mesh generator is described. The liaisons between finite elements and computer assisted design are discussed. Calculations for stamped shell type structures, axisymmetrical structures, structures with cyclic symmetry, and pure tridimensional structures are outlined. Applications to helicopter rotor hubs, and main rotor masts are demonstrated. Author (ESA)



**N85-31548\*#** Cincinnati Univ., Ohio. Dept. of Aerospace Engineering and Applied Mechanics.

**FINITE ELEMENT ANALYSIS OF NOTCH BEHAVIOR USING A STATE VARIABLE CONSTITUTIVE EQUATION**

L. T. DAME, D. C. STOFFER, and N. ABUELFOUTOUH *In* NASA. Lewis Research Center Nonlinear Constitutive Relations for High Temp. Appl., 1984 p 297-310 Jun. 1985 refs (Contract NAS3-23698; NAS3-23927; NAG3-511)

Avail: NTIS HC A16/MF A01 CSCL 20K

The state variable constitutive equation of Bodner and Partom was used to calculate the load-strain response of Inconel 718 at 649 C in the root of a notch. The constitutive equation was used with the Bodner-Partom evolution equation and with a second evolution equation that was derived from a potential function of the stress and state variable. Data used in determining constants for the constitutive models was from one-dimensional smooth bar tests. The response was calculated for a plane stress condition at the root of the notch with a finite element code using constant strain triangular elements. Results from both evolution equations compared favorably with the observed experimental response. The accuracy and efficiency of the finite element calculations also compared favorably to existing methods. Author

**N85-31582#** Centre d'Essais Aeronautique Toulouse (France). Lab. des Etudes de Materiaux Metalliques.

**INFLUENCE OF THE MOLDING JOINT PLANE ON THE FATIGUE RESISTANCE OF THE ALLOYS 7010 AND 7050. TEST REPORT NO. M1-631600 [INFLUENCE DU PLAN DE JOINT DE MATRICAGE SUR LA TENUE EN FATIGUE DES ALLIAGES 7010 ET 7050. PROCES-VERBAL M1-631600]**

29 May 1984 61 p refs *In* FRENCH Sponsored by Delegation Generale pour l'Armement (PV-M1-631600) Avail: NTIS HC A04/MF A01

Tensile, axial fatigue and pulsed pressure tests were carried out using samples from forged pieces employed in aircraft structures. Samples in the tangential direction show less fatigue resistance than the axial samples, especially in the bulged part of the molding. The low values of compression fatigue tests are attributed to the much larger sample volume. Author (ESA)

**N85-31577#** National Aerospace Lab., Amsterdam (Netherlands). Structures and Materials Div.

**MODIFICATIONS OF FLIGHT-BY-FLIGHT LOAD SEQUENCES TO PROVIDE FOR GOOD FRACTURE SURFACE READABILITY**

H. H. VANDERLINDEN 7 Feb. 1984 27 p refs Presented at AGARD SMP Specialists Meeting on Fatigue Crack Topograph., Siena, Italy, 4-5 Apr. 1984 Sponsored by Royal Netherlands Air Force Directorate of Materiel

(NLR-MP-84012-U; B8562381) Avail: NTIS HC A03/MF A01

In order to establish an inspection schedule for fatigue critical fastener holes in the wing lower skin of a fighter aircraft, crack growth data under realistic loading were obtained. Experimental determination of the data is unsatisfactory since the spectrum and load sequence do not mark the fracture surface well enough. Fractography of a specimen tested under modified FALSTAFF shows that scanning electron microscopy gives the best results. Goals, means of accomplishment, and results of a pilot program in which modifications of the load sequence were investigated are described. Simple center notched and complex representative specimens were used. A marker version of the original sequence is validated. Author (ESA)

**N85-32025#** National Aeronautical Lab., Bangalore (India).

**R AND D ACTIVITIES OF THE PROPULSION DIVISION**

P. A. PARANJPE *In* its R and D Programmes at the Natl. Aeron. Lab. p 59-76 1983 refs

Avail: NTIS HC A10/MF A01

The objective is to carry out applied research in the field of turbomachinery and combustion with a view to generating design data, developing new techniques and evolving computer based design aids. Prediction of heat transfer on turbine blades, with a turbulence model, the aerodynamics of turbomachinery stages, an

estimation of profile loss for turbomachinery blades, squeeze film dampers and film cooling studies of a large entry duct of an annular combustion chamber are discussed. R.J.F.

**N85-32026#** National Aeronautical Lab., Bangalore (India).

**R AND D ACTIVITIES OF THE STRUCTURAL SCIENCES DIVISION**

B. R. SOMASHEKAR *In* its R and D Programmes at the Natl. Aeron. Lab. p 77-93 1983 refs

Avail: NTIS HC A10/MF A01

The static and dynamic characteristics of flight structures are studied by analytical and experimental techniques in the broad areas of vibration and aeroelasticity, stress analysis and composite structures. Emphasis is placed on development of methods and facilities for large scale and practical applications. In addition, the design, fabrication and testing of various structural components including scaled models employing both metallic and non-metallic materials are undertaken. Static, dynamic, thermal and aeroelastic characteristics are studied. R.J.F.

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## GEOSCIENCES

Includes geosciences (general); earth resources; energy production and conversion; environment pollution; geophysics; meteorology and climatology; and oceanography.

**A85-40561#**

**A RING-VORTEX DOWNBURST MODEL FOR REAL-TIME FLIGHT SIMULATION OF SEVERE WIND SHEARS**

M. IVAN (Boeing Computer Services Co., Seattle, WA) *IN*: Flight Simulation Technologies Conference, St. Louis, MO, July 22-24, 1985, Technical Papers. New York, AIAA, 1985, p. 57-61. refs (AIAA PAPER 85-1749)

The present downburst phenomenon model is suitable for real time takeoff and landing simulations, and encompasses low altitude severe wind shears due either to downbursts of microbursts having circulatory wind flow patterns that resemble those noted in the Joint Airport Weather Studies project. The idealization of wind flow takes the form of a three-dimensional, axisymmetric circulatory flow field similar to that surrounding a horizontal ring vortex at an appropriate height above the ground. The flexibility incorporated in input parameter variation allows the simulation of a wide range of shear intensity levels and downburst sizes. O.C.

**A85-40562\*#** National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**COMPOSITE STATISTICAL METHOD FOR MODELING WIND GUSTS FOR AIRCRAFT SIMULATION**

J. R. SCHIESS (NASA, Langley Research Center, Hampton, VA) *IN*: Flight Simulation Technologies Conference, St. Louis, MO, July 22-24, 1985, Technical Papers. New York, AIAA, 1985, p. 62-68. (AIAA PAPER 85-1750)

This paper discusses the application of three statistical methods in combination to model wind gusts for use in aircraft flight simulation. The approach combines principal components analysis, time series analysis and probability distribution model to analyze and simulate wind gust components. Comparisons are given between wind gust components generated by the model and components measured onboard an aircraft. Author

**A85-41177#**

**ALTIMETRIC-GRAVIMETRIC FUNCTIONAL BOUNDARY VALUE PROBLEM [AL'TIMETRICO-GRAVIMETRICHESKAIA FUNKSIONAL'NAIA KRAEVAIA ZADACHA]**

L. D. STOIANOV Nabliudeniiia Iskusstvennykh Sputnikov Zemli, no. 23, 1984, p. 265-279. *In* Russian. refs

The Green integral formula is used to derive functional conditions for the anomalous potential. Values of the functionals

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over continental areas are calculated using measured values of the gravity anomaly and components of deflection of the vertical or geopotential number; over ocean areas they are calculated using measured values of the pure anomaly or boundary values of the potential. The functional problem is reduced to the determination of a finite-dimensional and unique geopotential which satisfies the conditions best in the least-squares sense. Four spherical solutions of the altimetric-gravimetric boundary value problem by a discrete description are proposed along with two solutions in a closed form by the generalization of the function of Stokes and Neumann (the Hotine kernel). B.J.

**A85-41395**

### **A NUMERICAL EXPERIMENT IN THE ALTIMETRY-GRAVIMETRY PROBLEM II**

F. SANSONI (Milano, Politecnico, Milan, Italy) and B. STOCK (Darmstadt, Technische Hochschule, West Germany) Manuscripta Geodaetica (ISSN 0340-8825), vol. 10, no. 1, 1985, p. 23-31. DFG-supported research. refs

A numerical study of an integral equation resulting from the so called altimetry-gravimetry problem II of physical geodesy is presented. In this mixed boundary value problem for the Laplace equation gravity anomalies are assumed to be known over land and gravity disturbances over the oceans. In particular, a discretization procedure for this integral equation is derived and the method is applied to a model which approaches physical reality in order to judge about its usefulness. Author

**A85-42173**

### **ELECTRA VERTICAL AIR MOTIONS IN SUMMER MONEX - USING THE AIRCRAFT AS AN AIR MOTION SENSOR AND NOTIFICATION OF A DATA LABELING ERROR**

R. L. GROSSMAN (Colorado, University, Boulder) and R. FRIESEN (National Center for Atmospheric Research, Boulder, CO) American Meteorological Society, Bulletin (ISSN 0003-0007), vol. 66, June 1985, p. 651-656. refs (Contract NSF ATM-82-06904)

In the summer of 1979, a regional Global Weather Experiment called the Summer Monsoon Experiment, or 'SMONEX', was conducted to investigate the Asian southwest monsoon. It is presently noted that the SMONEX Electra aircraft one minute-averaged data tape and microfilm is mislabeled 'vertical velocity', in place of 'aircraft velocity'. An aircraft response method is accordingly presented for obtaining vertical windspeed data from the NCAR Electra. An error analysis of the aircraft method equations is also presented. O.C.

**A85-42469**

### **GEOPOTENTIAL RESEARCH MISSION - STATUS REPORT**

S. M. YIONOULIS and V. L. PISACANE (Johns Hopkins University, Laurel, MD) IEEE Transactions on Geoscience and Remote Sensing (ISSN 0196-2892), vol. GE-23, July 1985, p. 511-516. refs

The Geopotential Research Mission (GRM) is a NASA mission planned to produce more exact measurements of the gravitational and geomagnetic fields of the earth. A status report on the progress of the mission is presented, with emphasis given to the engineering requirements of the gravitational field measurements. The guidance and measurements instruments of the GRM spacecraft are described, including the proof-mass measurement system; the disturbance compensation system (DISCOS); and an optical interferometric system for proof-mass measurements. A schematic diagram of the GRM spacecraft is presented. I.H.

**N85-30451\*#** National Aeronautics and Space Administration. Goddard Space Flight Center, Greenbelt, Md.

### **MIZEX, 1984, NASA CV-990 FLIGHT REPORT**

May 1985 155 p refs Submitted for publication (NASA-TM-86216; NAS 1.15:86216) Avail: NTIS HC A08/MF A01 CSCL 08L

During June/July 1984, the NASA CV-990 Airborne Laboratory was utilized in a mission to overfly the Fram Strait/East Greenland Sea marginal ice zone (MIZ) during the main summer marginal

ice zone experiment (MIZEX '84). The eight data flights were coordinated where possible with overpasses of the Nimbus-7 satellite, and with measurement of sea ice, open ocean, and atmospheric properties at the surface. The surface research teams were based on seven research vessels, some with helicopters: (1) M/V Kvibjorn, (2) M/V Polarqueen; (3) M/S Haakon Mosby; (4) a M/S H.U. Sverdrup, all from Norway; (5) F/S Polarstern from the Federal Republic of Germany; and (6) the USNS Lynch from the USA. There were also coordinated flights with the NRL P3, NOAA P3, Canadian CV580, and the French B-17 during the overlap portions of their respective missions. Analysis of the real-time data acquired during the mission and uncalibrated data stored on tape has served to indicate the mission was over 90% successful. Author

**N85-30558#** Virginia Polytechnic Inst. and State Univ., Blacksburg. Dept. of Engineering Science and Mechanics.

### **A SURVEY OF THE TURBULENCE IN THE MARINE SURFACE LAYER FOR THE OPERATION OF LOW-REYNOLDS NUMBER AIRCRAFT**

H. W. TIELEMAN Mar. 1985 132 p (Contract N00014-83-K-0658) (AD-A154133; VPI-E-85-10) Avail: NTIS HC A07/MF A01 CSCL 04B

The design and operation of remotely piloted aircraft at low-Reynolds numbers and at extremely low altitudes above the ocean requires low level wind input data. Surface winds and gusts are known to have a strong influence on the operation of aircraft near the surface and can cause serious control problems. In general, cross winds, wind shear and gusts encountered by low-flying aircraft pose significant problems in their operation. Although numerous experimental studies have been made in the surface layer and boundary layer over the ocean, the ability to apply the currently available information to the design and operation of aircraft is limited. This report reviews the current experimental knowledge of the marine atmospheric surface layer and discusses the nature and quality of the reported data as well as their applicability as input to the design and operation of low-flying aircraft. GRA

**N85-30560#** SRI International Corp., Menlo Park, Calif.

### **COMPARISON OF THE ELECTROMAGNETIC PROPERTIES OF LIGHTNING AND EMP (ELECTROMAGNETIC PULSE): RESULTS OF RECENT LIGHTNING STUDIES Final Technical Report, 1 Apr. 1982 - 30 Jun. 1983**

J. E. NANEVICZ, E. F. VANCE, J. M. HAMM, and D. M. BUBENIK 30 Jun. 1983 124 p (Contract DNA001-82-C-0190; DNA PROJ. Q99-QAXC) (AD-A154325; AD-E301685; DNA-TR-82-204) Avail: NTIS HC A06/MF A01 CSCL 04A

This report presents the results of the first phase of a program conducted by SRI International in an effort to address and resolve issues concerning the comparative interactions of lightning and EMP with aircraft. The program concentrated on using recently generated analytical and experimental data and interacting with lightning workers in an effort to define the current state of knowledge regarding the electromagnetic properties of lightning. This program was motivated by suggestions that there might be sufficient similarity between the effects of lightning and EMP that consideration of the electromagnetic effects of one would also suffice for the other. GRA

### **N85-30568#** National Weather Service, Salt Lake City, Utah. **AEV LOCAL VERIFICATION FOR AVIATION, PRECIPITATION, AND TEMPERATURE PROGRAMS: AV, REL, TEM**

L. B. DUNN Mar. 1985 34 p (PB85-179125; NOAA-NWS-WRCP-42) Avail: NTIS HC A03/MF A01 CSCL 04B

These three programs take advantage of the locally archived verification data provided by the AEV software. AFOS alpha-numeric and graphic products are created which display statistical results for local and MOS forecasts. The programs are extremely flexible in allowing the user to define the criteria of

verification. The programs are written in Data General FORTRAN IV, revised 5.57. The programs are initiated from the AFOS ADM or the Dasher and AFOS must be running. Author (GRA)

**N85-31648#** Air Force Wright Aeronautical Labs., Wright-Patterson AFB, Ohio. Aero-Propulsion Lab.  
**AIR FORCE FEDERAL PHOTOVOLTAIC UTILIZATION PROGRAM**

J. F. WISE 1985 15 p  
(Contract DE-AI01-79CS-30077)  
(DE85-010812; DOE/CS-30077/T5) Avail: NTIS HC A02/MF A01

The technical and financial history of the Federal Photovoltaic Utilization Program within the US Air Force is briefly reported. The projects included microwave sites at Edwards Air Force Base, communication vans at Nellis Air Force Base Tactical Range, photovoltaic homes at Tyndal and Kirtland Air Force Bases, a community energy system at McClellan Air Force Base, and an aircraft arresting system that employs a photovoltaic power supply to drive engines that erect and remove barriers for keeping aircraft from travelling off the end of a runway. DOE

**N85-31736#** European Space Agency, Paris (France).  
**ON THE STATE OF KNOWLEDGE ON METEOROLOGICALLY CAUSED ICING OF AIRCRAFT IN CLOUDS**

H. E. HOFFMANN Aug. 1984 65 p refs Transl. into ENGLISH of "Zum Kenntnisstand: Meteorol. bedingte Vereisung von Luftfahrzeugen in Wolken" rept. DFVLR-Mitt-83-12 DFVLR, Oberpfaffenhofen, West Germany, 1983 Original language report previously announced as N84-17763  
(ESA-TT-861; DFVLR-MITT-83-12) Avail: NTIS HC A04/MF A01; original German version available from DFVLR, Cologne DM 20.50

The international status of knowledge is presented. Besides a series of special reports the following reports are used as a basis: The Federal Aviation Regulations (FAR) today valid - respectively reports from 1949-1956, on which they are founded - and publications of AGARD and German Military Geophysical Office in the last time. The presentation of status of knowledge is arranged according to the following topics: cloudphysical parameters (temperature, liquid water content, particle size), cloud parameters (class of clouds, range, altitude, orography), synoptics (fronts, air masses), calculation of the ice accretion and the derivation of empirical equations and diagrams for the changing of the aerodynamic coefficients. ESA

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### MATHEMATICAL AND COMPUTER SCIENCES

Includes mathematical and computer sciences (general); computer operations and hardware; computer programming and software; computer systems; cybernetics; numerical analysis; statistics and probability; systems analysis; and theoretical mathematics.

**A85-39975**

**OPTIMIZATION OF CONTROL SYSTEMS USING THE MINIMAX CRITERION [OPTIMIZATSIYA SISTEM UPRAVLENIYA PO MINIMAKSNOMU KRITERIIU]**

V. M. KEIN Moscow, Izdatel'stvo Nauka, 1985, 248 p. In Russian. refs

The book is concerned with applied control problems involving indeterminacy caused by external perturbations and inaccurate measurements of the state of the controlled system. Methods for analyzing the behavior of the controlled system under extreme (most unfavorable) perturbations are discussed, and ways to estimate the guaranteed control accuracy under certain constraints on the perturbations are proposed. Attention is also given to methods of control synthesis ensuring the potentially obtainable

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accuracy under conditions of extreme perturbations. The discussion is illustrated by examples of solutions to practical problems. V.L.

**A85-40331#**

**A DATA-PROCESSING PROCEDURAL CHAIN IN STRUCTURAL MECHANICS [EINE DV-PROZESSKETTE IN DER STRUKTURMECHANIK]**

B. EVERS Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 30 p. In German. refs  
(DGLR PAPER 84-115; MBB-UT-07-84)

The employment of computer programs for the conduction of numerical analyses related to the various areas of the structural mechanics of aircraft design is considered. It is found that many of these programs represent 'insular' solutions for an individual problem. It is, therefore, necessary for the user to give attention to the transfer of data from the output of one program to the input of the next program. An automated data processing approach would reduce the occurrence of errors and increase the cost efficiency of the computational operations. The Automatic System of Strength Analysis of Complex Structures (ASSACOS) represents the first step in the development of the considered automated system. ASSACOS contains modules for the calculation of static strength values and for lifetime and crack-propagation predictions. However, ASSACOS does not yet present an ideal solution regarding automated data processing. For this reason, the development of an integrated structural mechanics data processing system (Issy) is being considered. A central feature is the Structure Data Base (SDB). G.R.

**A85-40332#**

**USE OF CAD/CAM SYSTEMS DURING THE DEVELOPMENT/CONSTRUCTION OF THE A320 [NUTZUNG DES CAD/CAM-SYSTEMS BEI DER ENTWICKLUNG/KONSTRUKTION DER A320]**

W. RIECKMANN (Messerschmitt-Boelkow-Blohm GmbH, Hamburg, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 22 p. In German.

(DGLR PAPER 84-116; MBB-UT-09-84)

The use of CAD/CAM in the project definition, predesign work, and in detailed design of the A320 aircraft is described and discussed. The personnel, hardware, and software requirements for using CAD/CAM to produce complete specifications are addressed. The use of technical-administrative and geometric information by CAD/CAM in the design process is examined. Examples of CAD/CAM work in the predesign and detailed design phases are shown, and the results using CAD/CAM are compared with those from manual work. C.D.

**A85-40337**

**DYNAMICS OF HELICOPTER AIR COMBAT**

W. B. HERBST and R. POLIS (Messerschmitt-Boelkow-Blohm GmbH, Munich, West Germany) Deutsche Gesellschaft fuer Luft- und Raumfahrt, Jahrestagung, Hamburg, West Germany, Oct. 1-3, 1984. 13 p. refs

(DGLR PAPER 84-124; MBB-S/PUB/144)

A discussion is presented concerning the features of air-to-air engagements between helicopters, as disclosed in the course of computer simulations. Extensive analogies are found between helicopter combat maneuvering and fixed wing aircraft engagements. Attention is also given to the case of fixed wing vs helicopter combat. The weapons assumed in the present series of simulations encompass 12.7-mm and 27-mm cannon, 'Stinger-type' guided missiles, and short range 'Sidewinder-type' IR-guided missiles. Combat maneuvers are simulated in terms of 'maneuver cycles' which are constrained by both aerodynamic/structural limits and by available excess propulsion power. O.C.

## 15 MATHEMATICAL AND COMPUTER SCIENCES

**A85-40556\*** # Information and Control Systems, Inc., Hampton, Va.

### **OPTIMAL GENERALIZED MULTISTEP INTEGRATION FORMULAE FOR REAL-TIME DIGITAL SIMULATION**

D. D. MOERDER and N. HALYO (Information and Control Systems, Inc., Hampton, VA) IN: Flight Simulation Technologies Conference, St. Louis, MO, July 22-24, 1985, Technical Papers. New York, AIAA, 1985, p. 22-28. refs

(Contract NAS1-17161)

(AIAA PAPER 85-1740)

The problem of discretizing a dynamical system for real-time digital simulation is considered. Treating the system and its simulation as stochastic processes leads to a statistical characterization of simulator fidelity. A plant discretization procedure based on an efficient matrix generalization of explicit linear multistep discrete integration formulae is introduced, which minimizes a weighted sum of the mean squared steady-state and transient error between the system and simulator outputs.

Author

**A85-40564\***

### **A REAL TIME EXECUTIVE FOR THE CONTROL OF A MULTICOMPUTER SIMULATION COMPLEX**

J. H. CROFT (Boeing Co., Seattle, WA) IN: Flight Simulation Technologies Conference, St. Louis, MO, July 22-24, 1985, Technical Papers. New York, AIAA, 1985, p. 81-91.

(AIAA PAPER 85-1754)

The control and synchronization of computers in a real time environment requires a sophisticated 'simulation executive', such as that developed for the B-1B Avionics real time simulator complex of four computers connected by shared memory. In order to furnish the required interfaces, the simulation software encompasses vehicle, weapon system, defensive system, and radar data simulations, each residing in one of the four computers together with the simulation executive. The executive furnishes the interface between the simulation software and hardware, as well as complete process and input/output control.

O.C.

**A85-40917**

### **DARPA STRESSING DEVELOPMENT OF PILOT'S ASSOCIATE SYSTEM**

K. J. STEIN Aviation Week and Space Technology (ISSN 0005-2175), vol. 122, April 22, 1985, p. 69, 71, 73, 74.

The Defense Advanced Research Projects Agency has undertaken a major applications effort aimed at the development of a 'pilot's associate' airborne computer expert system useful in air-to-ground and air-to-air combat missions. An important element of this research program is a pilot/vehicle interface exploiting such technologies as speed recognition. Parallel processing architectures will be essential, as will advances in microelectronic fabrication technology. Manufacturers participating in these research efforts will be expected to have simulation facilities that can furnish realistic, real-time interactive demonstrations.

O.C.

**A85-40932\*** # National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### **A TIME-ACCURATE MULTIPLE-GRID ALGORITHM**

D. C. JESPERSEN (NASA, Ames Research Center, Moffett Field, CA) IN: Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers. New York, AIAA, 1985, p. 58-66. refs

(AIAA PAPER 85-1493)

A time-accurate multiple-grid algorithm is described. The algorithm allows one to take much larger time steps with an explicit time-marching scheme than would otherwise be the case. Sample calculations of a scalar advection equation and the Euler equations for an oscillating airfoil are shown. For the oscillating airfoil, time steps an order of magnitude larger than the single-grid algorithm are possible.

Author

**A85-40933\*** # Boeing Co., Seattle, Wash.

### **GMRES ACCELERATION OF COMPUTATIONAL FLUID DYNAMICS CODES**

L. B. WIGTON, N. J. YU, and D. P. YOUNG (Boeing Co., Seattle, WA) IN: Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers. New York, AIAA, 1985, p. 67-74. refs

(Contract NAS2-11851)

(AIAA PAPER 85-1494)

The generalized minimal residual algorithm (GMRES) is a conjugate-gradient like method that applies directly to nonsymmetric linear systems of equations. In this paper, GMRES is modified to handle nonlinear equations characteristic of computational fluid dynamics. Attention is devoted to the concept of preconditioning and the role it plays in assuring rapid convergence. A formulation is developed that allows GMRES to be preconditioned by the solution procedures already built into existing computer codes. Examples are provided that demonstrate the ability of GMRES to greatly improve the robustness and rate of convergence of current state-of-the-art fluid dynamics codes. Theoretical aspects of GMRES are presented that explain why it works. Finally, the advantage GMRES enjoys over related methods such as conjugate gradients are discussed.

Author

**A85-40947\*** # Rockwell International Science Center, Thousand Oaks, Calif.

### **A FAST, TIME-ACCURATE UNSTEADY FULL POTENTIAL SCHEME**

V. SHANKAR, H. IDE, J. GORSKI (Rockwell International Science Center, Thousand Oaks, CA), and S. OSHER (California, University, Los Angeles) IN: Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers. New York, AIAA, 1985, p. 214-227. refs

(Contract NAS1-15820)

(AIAA PAPER 85-1512)

The unsteady form of the full potential equation is solved in conservation form by an implicit method based on approximate factorization. At each time level, internal Newton iterations are performed to achieve time accuracy and computational efficiency. A local time linearization procedure is introduced to provide a good initial guess for the Newton iteration. A novel flux-biasing technique is applied to generate proper forms of the artificial viscosity to treat hyperbolic regions with shocks and sonic lines present. The wake is properly modeled by accounting not only for jumps in  $\phi$ , but also for jumps in higher derivatives of  $\phi$ , obtained by imposing the density to be continuous across the wake. The far field is modeled using the Riemann invariants to simulate nonreflecting boundary conditions. The resulting unsteady method performs well which, even at low reduced frequency levels of 0.1 or less, requires fewer than 100 time steps per cycle at transonic Mach numbers. The code is fully vectorized for the CRAY-XMP and the VPS-32 computers.

Author

**A85-40955\*** # Calspan Field Services, Inc., Arnold AFS, Tenn.

### **A 3-D CHIMERA GRID EMBEDDING TECHNIQUE**

J. A. BENEK (Calspan Field Services, Inc., Arnold Air Force Station, TN), P. G. BUNING, and J. L. STEGER (NASA, Ames Research Center, Moffett Field, CA) IN: Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers. New York, AIAA, 1985, p. 322-331. refs

(AIAA PAPER 85-1523)

A three-dimensional (3-D) chimera grid-embedding technique is described. The technique simplifies the construction of computational grids about complex geometries. The method subdivides the physical domain into regions which can accommodate easily generated grids. Communication among the grids is accomplished by interpolation of the dependent variables at grid boundaries. The procedures for constructing the composite mesh and the associated data structures are described. The method is demonstrated by solution of the Euler equations for the transonic flow about a wing/body, wing/body/tail, and a configuration of three ellipsoidal bodies.

Author

**A85-40956\***# National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

**OVERSET GRIDS IN COMPRESSIBLE FLOW**

S. EBERHARDT (NASA, Ames Research Center, Moffett Field, CA) and D. BAGANOFF (Stanford University, CA) IN: *Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers*. New York, AIAA, 1985, p. 332-339. refs

(AIAA PAPER 85-1524)

Numerical experiments have been performed to investigate the importance of boundary data handling with overset grids in computational fluid dynamics. Experience in using embedded grid techniques in compressible flow has shown that shock waves which cross grid boundaries become ill defined and convergence is generally degraded. Numerical boundary schemes were studied to investigate the cause of these problems and a viable solution was generated using the method of characteristics to define a boundary scheme. The model test problem investigated consisted of a detached shock wave on a 2-dimensional Mach 2 blunt, cylindrical body. Author

**A85-40958#**

**TWO- AND THREE-DIMENSIONAL GRID GENERATION FOR INTERNAL FLOW APPLICATIONS OF COMPUTATIONAL FLUID DYNAMICS**

B. K. SONI (Sverdrup Technology, Inc., Arnold Air Force Station, TN) IN: *Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers*. New York, AIAA, 1985, p. 351-359. refs

(AIAA PAPER 85-1526)

A systematic procedure for grid generation which can provide computational grids for a wide range of geometries related to internal flow problems is presented. The process uses several techniques either separately or in combination to quickly and economically generate grids for arbitrary geometries. The computational mesh is formed by using algebraic methods and/or partial differential equation methods with proper forcing functions. Grid clustering is accomplished with either exponential or hyperbolic tangent routines which allow the user to specify a desired grid point distribution. Grid smoothing is accomplished with elliptic solvers, spline techniques, and averaging algorithms. The presence of solid obstacles interior to the computational mesh is addressed using an automated patching technique. The builtin geometry modeling capability and the development of an optimal transfinite interpolation method are the salient features of the methods presented which result in a significant time savings in a given geometry/grid-generation application. Author

**A85-40961\***# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**AN EFFICIENT ITERATION STRATEGY FOR THE SOLUTION OF THE EULER EQUATIONS**

R. W. WALTERS and D. L. DWOYER (NASA, Langley Research Center, Hampton, VA) IN: *Computational Fluid Dynamics Conference, 7th, Cincinnati, OH, July 15-17, 1985, Technical Papers*. New York, AIAA, 1985, p. 381-393. refs

(AIAA PAPER 85-1529)

A line Gauss-Seidel (LGS) relaxation algorithm in conjunction with a one-parameter family of upwind discretizations of the Euler equations in two-dimensions is described. The basic algorithm has the property that convergence to the steady-state is quadratic for fully supersonic flows and linear otherwise. This is in contrast to the block ADI methods (either central or upwind differenced) and the upwind biased relaxation schemes, all of which converge linearly, independent of the flow regime. Moreover, the algorithm presented here is easily enhanced to detect regions of subsonic flow embedded in supersonic flow. This allows marching by lines in the supersonic regions, converging each line quadratically, and iterating in the subsonic regions, thus yielding a very efficient iteration strategy. Numerical results are presented for two-dimensional supersonic and transonic flows containing both oblique and normal shock waves which confirm the efficiency of the iteration strategy. Author

**A85-41339\***# Technion - Israel Inst. of Tech., Haifa.

**PURSUIT-EVASION GAME ANALYSIS IN A LINE OF SIGHT COORDINATE SYSTEM**

J. SHINAR (Technion - Israel Institute of Technology, Haifa) and A. DAVIDOVITZ Israel Annual Conference on Aviation and Astronautics, 27th, Tel Aviv and Haifa, Israel, Feb. 27, 28, 1985, Paper. 11 p. refs

(Contract NCCW-4)

The paper proposes to use line of sight coordinates for the analysis of pursuit-evasion games. The advantage of this method for two-target games is shown to be evident. As a demonstrative example the game of two identical cars is formulated and solved in such coordinate systems. A new type of singular surface, overlooked in a previous study of the same problem, is discovered as a consequence of the simplicity of the solution. Author

**A85-41743\***# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

**IMPLICIT FLUX-SPLIT SCHEMES FOR THE EULER EQUATIONS**

J. L. THOMAS, R. W. WALTERS (NASA, Langley Research Center, Hampton, VA), and B. VAN LEER (Delft, Technische Hogeschool, Netherlands) AIAA, Fluid Dynamics and Plasmadynamics and Lasers Conference, 18th, Cincinnati, OH, July 16-18, 1985. 19 p. refs

(AIAA PAPER 85-1680)

Recent progress in the development of implicit algorithms for the Euler equations using the flux-vector splitting method is described. Comparisons of the relative efficiency of relaxation and spatially-split approximately factored methods on a vector processor for two-dimensional flows are made. For transonic flows, the higher convergence rate per iteration of the Gauss-Seidel relaxation algorithms, which are only partially vectorizable, is amply compensated for by the faster computational rate per iteration of the approximately factored algorithm. For supersonic flows, the fully-upwind line-relaxation method is more efficient since the numerical domain of dependence is more closely matched to the physical domain of dependence. A hybrid three-dimensional algorithm using relaxation in one coordinate direction and approximate factorization in the cross-flow plane is developed and applied to a forebody shape at supersonic speeds and a swept, tapered wing at transonic speeds. Author

**A85-42666#**

**DEVELOPING AN OFF-LINE ENVIRONMENT FOR TESTING REAL TIME AERODYNAMICS SIMULATION**

A. WARD and J. HOYER (Singer Co., Link Flight Simulation Div., Binghamton, NY) AIAA, Flight Simulation Technologies Conference, St. Louis, MO, July 22-24, 1985. 8 p.

(AIAA PAPER 85-1751)

The Automated Test Guide (ATG), a software package designed to run several major sections of a flight simulator Acceptance Test Procedure automatically, is described. The automated sections include aircraft performance, stability and control, and engine performance. Common master driver routines are used to process test unique command files; these routines carry out test procedures and record test results on-line. The most significant features of the ATG are the use of the on-line modules in an off-line mode and the resulting capability to execute the same tests by the same methods on-line and off-line. V.L.

**A85-42675#**

**IDENTIFICATION OF LINEAR DYNAMIC CONTROL PLANTS BY MEANS OF SIGNAL EXPANSION ON THE BASIS OF THE WALSH FUNCTION [IDENTYFIKACJA LINIOWYCH OBIEKTOW DYNAMICZNYCH METODA ROZKLADU SYGNALOW WZGLEDEM FUNKCJI WALSHA]**

J. GALAJ (Warszawa, Politechnika, Warsaw, Poland) *Archiwum Automatyki i Telemekhaniki* (ISSN 0004-072X), vol. 29, no. 4, 1984, p. 509-521. In Polish. refs

A method of discrete spectral identification of linear multivariable control plants is presented. It relies on the expansion of input and output signals into discrete orthogonal series making use of

## 15 MATHEMATICAL AND COMPUTER SCIENCES

the Walsh function. A numerical identification algorithm is worked out. Its successive computational steps are described in detail. For a single-rotor helicopter, considered as a control plant, a digital simulation of the identification system was carried out. Results of the digital simulation provide the answer to some problems of discrete spectral identification, e.g., to the question of the influence of the duration of discretization period on the overall identification error. Author

**A85-42689#**

### **ON THE CONTROLLABILITY LIMIT OF A HUMAN OPERATOR WHEN USING A BANG-BANG TYPE CONTROLLER**

N. MORIZUMI and H. KIMURA Kyushu University, Technology Reports (ISSN 0023-2718), vol. 58, March 1985, p. 153-159. In Japanese, with abstract in English. refs

A discussion is made on the controllability limit of a human operator, who is engaged in a compensatory control task in a closed loop system by means of a bang-bang type controller. An unstable second-order system is employed as the controlled element, and the regulatory behavior of the system is examined. The existence of limit cycles of the system is theoretically analyzed in the phase plane, and the controllability limit is determined from the conditions of the stable limit cycle. An experiment is conducted to verify the theoretical result. The controllability limit which is predicted theoretically is compared with that obtained experimentally. It is shown that the theory gives good insight into the controllability limit of the human operator. Author

**A85-42894\*#** National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

### **PUTTING THE 'SUPER' IN SUPERCOMPUTERS**

C. SCHULBACH (NASA, Ames Research Center, Moffett Field, CA) Aerospace America (ISSN 0740-722X), vol. 23, Aug. 1985, p. 56-58, 60.

Computers used for numerical simulations of physical phenomena, e.g., flowfields, meteorology, structural analysis, etc., replace physical experiments that are too expensive or impossible to perform. The problems considered continually become increasingly more complex and thus demand faster processing times to do all necessary computations. The effects components technologies have on computer speed are leveling off, leaving new architectures and programming as the only currently viable means to upgrade speed. Parallel computations, either in the form of array processors, assembly line processing or multiprocessors are being explored using existing microprocessor technologies. Slower hardware configurations can also be made equivalent to faster supercomputers by economic programming. The availability of rudimentary parallel architecture supercomputers for general industrial use is increasing. Scientific applications continue to drive the development of more sophisticated parallel machines. M.S.K.

**A85-43240#**

### **APPLICATION OF A NEW TYPE OF POLE COLLOCATION EQUATIONS TO DESIGNING THE CONTROL LAW OF A BI-INPUT-MULTI-OUTPUT SYSTEM**

S. LU (Nanjing Aeronautical Institute, People's Republic of China) Acta Aeronautica et Astronautica Sinica, vol. 6, Feb. 1985, p. 13-20. In Chinese, with abstract in English. refs

**N85-30684#** Sandia Labs., Albuquerque, N. Mex.

### **SANDRAG: A COMPUTER CODE FOR PREDICTING DRAG OF BODIES OF REVOLUTION AT ZERO ANGLE OF ATTACK IN INCOMPRESSIBLE FLOW**

W. P. WOLFE and W. L. OBERKAMPF Apr. 1985 78 p refs (Contract DE-AC04-76DP-00789) (DE85-011170; SAND-85-0515) Avail: NTIS HC A05/MF A01

A design method is presented for calculating the flow field and drag of bodies of revolution at zero angle of attack in compressible flow. The body pressure distribution, viscous shear stress, and boundary layer separation point are calculated by a combination of a potential flow method and boundary layer techniques. The potential solution is obtained by modeling the

body with an axial distribution of source/sink elements whose strengths vary linearly along their length. Both the laminar and turbulent boundary layer solutions use momentum integral techniques which were modified to account for the effects of surface roughness. An existing technique for estimating the location of transition was also modified to include surface roughness. Empirical correlations are developed to estimate the base pressure coefficient on a wide variety of geometries. Body surface pressure distributions and drag predictions are compared with experimental data for artillery projectiles, conical, and flared bodies. Very good agreement between the present method and experiment is obtained. DOE

**N85-30706\*#** Draper (Charles Stark) Lab., Inc., Cambridge, Mass.

### **DEVELOPMENT AND EVALUATION OF A FAULT-TOLERANT MULTIPROCESSOR (FTMP) COMPUTER. VOLUME 2: FTMP SOFTWARE Final Report**

J. H. LALA and T. B. SMITH, III May 1983 234 p refs 4 Vol.

(Contract NAS1-15336)

(NASA-CR-166072; NAS 1.26:166072; CSDL-R-1601-VOL-2)

Avail: NTIS HC A11/MF A01 CSCL 09B

The software developed for the Fault-Tolerant Multiprocessor (FTMP) is described. The FTMP executive is a timer-interrupt driven dispatcher that schedules iterative tasks which run at 3.125, 12.5, and 25 Hz. Major tasks which run under the executive include system configuration control, flight control, and display. The flight control task includes autopilot and autoland functions for a jet transport aircraft. System Displays include status displays of all hardware elements (processors, memories, I/O ports, buses), failure log displays showing transient and hard faults, and an autopilot display. All software is in a higher order language (AED, an ALGOL derivative). The executive is a fully distributed general purpose executive which automatically balances the load among available processor triads. Provisions for graceful performance degradation under processing overload are an integral part of the scheduling algorithms. Author

**N85-30748#** RAND Corp., Santa Monica, Calif.

### **REGRESSION DIAGNOSTICS IN PRACTICE: EXPERIENCES FROM MODELLING JET ENGINE COSTS**

J. B. GARFINKLE and J. L. BIRKLER Jun. 1983 15 p (AD-A154199; AD-F630665; RAND/P-6896) Avail: NTIS HC A02/MF A01 CSCL 14A

This paper describes how regression diagnostics were used to help develop revised cost-estimating relationships for jet engines. The goal was to derive meaningful, yet easy to use models based on an updated collection of few observations and many variables. First, specific criteria were established for selecting explanatory variables. A variety of numerical and graphical techniques were then used to critique candidate models by examining residuals and evaluating the influence of individual engines. The final models are not only intuitively satisfying, but generally provide better predictions and are easier to use than earlier models. Additionally, the user is provided with a greater understanding of the design and sensitivity of the models, and therefore a better understanding of the actual estimates. GRA

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## PHYSICS

Includes physics (general); acoustics; atomic and molecular physics; nuclear and high-energy physics; optics; plasma physics; solid-state physics; and thermodynamics and statistical physics.

A85-40572

# EXTRACTION OF HELICOPTER-RADIATED NOISE BY FREQUENCY DOMAIN PROCESSING

R. F. DWYER (U.S. Naval Underwater Systems Center, New London, CT) Acoustical Society of America, Journal (ISSN 0001-4966), vol. 78, July 1985, p. 95-99. Navy-supported research. refs

An approaching UH-1 helicopter was used as acoustic source in the reported investigation. This type of helicopter has two blades on the main and tail rotors. Its radiated noise field has been extensively studied both experimentally and theoretically. The investigation is concerned with extracting the main rotor radiated noise components so that an autocorrelation function estimate of a desired signal can be improved. The components are extracted by first transforming the data into the frequency domain by a discrete Fourier transform, passing the transformed data through an ideal nonlinearity and transforming back into the time domain. The considered method relies on the fact that periodically occurring impulses produce a harmonically related line spectrum. It is shown that the narrow-band radiated components of a UH-1 helicopter operating under the conditions discussed and producing blade slap can be extracted by using frequency-domain processing. G.R.

A85-41646

# AVERAGE FORCE ACTING ON A SMALL SPHERE IN A TRAVELING-WAVE FIELD IN A VISCOUS FLUID

S. D. DANILOV (AN SSSR, Akusticheskii Institut, Moscow, USSR) Soviet Physics - Acoustics (ISSN 0038-562X), vol. 31, Jan.-Feb. 1985, p. 26-28. Translation. refs

The average force on a spherical particle which is small relative to the wavelength of the sound in a plane wave propagating in a viscous fluid is investigated analytically, extending the findings of Westervelt (1951) and Danilov and Mironov (1984) to account for acoustic streaming around the particle. It is found that streaming has significant effects and must be taken into account along with all other second-order phenomena in calculating the average force. In one limiting case the average force is much smaller than the radiation pressure force, the majority of the acoustic momentum flux being transported away by streaming, but is still greater than the average force in the corresponding ideal-fluid problem. T.K.

A85-41803

# CRITICAL ASSESSMENT OF THERMOPHYSICAL PROPERTIES DATA OF COMBUSTION GASES FOR CALCULATING THE PERFORMANCE OF GAS TURBINE

N. MASUNAGA, T. HOSHINO, and A. NAGASHIMA (Keio University, Yokohama, Japan) IN: 1983 Tokyo International Gas Turbine Congress, Tokyo, Japan, October 23-29, 1983, Proceedings. Volume 1. Tokyo, Gas Turbine Society of Japan, 1984, p. 321-328. refs

A consistent set of simple equations of the thermodynamic and transport properties of the combustion products have been developed for gas turbine calculations based on the critically evaluated data and on the recent theory. The properties considered are the density, the heat capacity at constant pressure, the enthalpy, the entropy, the viscosity, and the thermal conductivity. The properties of the combustion products of various fuel at various air/fuel ratios can be calculated using these equations. The temperature and pressure ranges are up to 2000 K and up to 10 MPa. Author

A85-42044

# AN EXPERIMENTAL INVESTIGATION OF THE GENERATION AND CONSEQUENCES OF ACOUSTIC WAVES IN AN AXIAL FLOW COMPRESSOR LARGE AXIAL SPACINGS BETWEEN BLADE ROWS

R. PARKER and S. A. T. STONEMAN (Swansea, University College, Wales) Journal of Sound and Vibration (ISSN 0022-460X), vol. 99, March 22, 1985, p. 169-182. Research supported by Rolls Royce, Ltd. and SERC. refs

The excitation of acoustic waves by vortex shedding from the inlet guide vanes in the annulus of a single-stage, low-speed axial-flow compressor test rig is investigated experimentally, in an effort to examine the assumptions made in the study of Parker (1984) and to provide data for mathematical models of these phenomena. The experimental setup and the transducers used to measure the operating and acoustic parameters are described in detail and illustrated with photographs and drawings, and the results are presented graphically. It is found that each mode excited can be associated with several excitation frequencies of the rotor blades, indicating forced blade vibration due to acoustic resonances. T.K.

N85-30766\*# Bolt, Beranek, and Newman, Inc., Cambridge, Mass.

# A STUDY OF INTERIOR NOISE LEVELS, NOISE SOURCES AND TRANSMISSION PATHS IN LIGHT AIRCRAFT Final Report

R. E. HAYDEN, B. S. MURRAY, and M. A. THEOBALD Jul. 1983 191 p refs

(Contract NAS1-16138)

(NASA-CR-172152; NAS 1.26:172152; BBN-4704) Avail: NTIS HC A09/MF A01 CSCL 20A

The interior noise levels and spectral characteristics of 18 single- and twin-engine propeller-driven light aircraft, and source-path diagnosis of a single-engine aircraft which was considered representative of a large part of the fleet were studied. The purpose of the flight surveys was to measure internal noise levels and identify principal noise sources and paths under a carefully controlled and standardized set of flight procedures. The diagnostic tests consisted of flights and ground tests in which various parts of the aircraft, such as engine mounts, the engine compartment, exhaust pipe, individual panels, and the wing strut were instrumented to determine source levels and transmission path strengths using the transfer function technique. Predominant source and path combinations are identified. Experimental techniques are described. Data, transfer function calculations to derive source-path contributions to the cabin acoustic environment, and implications of the findings for noise control design are analyzed. E.A.K.

N85-30767\*# National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

# EFFECTS OF PROPELLER ROTATION DIRECTION ON AIRPLANE INTERIOR NOISE LEVELS

C. M. WILLIS, W. H. MAYES, and E. F. DANIELS Washington Jul. 1985 34 p refs

(NASA-TP-2444; L-15892; NAS 1.60:2444) Avail: NTIS HC A03/MF A01 CSCL 20A

Interior noise measurements for upsweeping and downsweeping movement of the propeller blade tips past the fuselage were made on a twin-engine airplane and on two simplified fuselage models. Changes in interior noise levels of as much as 8 dB reversal of propeller rotation direction were measured for some configurations and test conditions. Author



## 16 PHYSICS

**N85-30768\*** # Columbia Univ., New York. Dept. of Civil Engineering and Engineering Mechanics.  
**AIRCRAFT CABIN NOISE PREDICTION AND OPTIMIZATION Final Report**

R. VAICAITIS Jul. 1985 85 p  
(Contract NSG-1450)  
(NASA-CR-175982; NAS 1.26:175982) Avail: NTIS HC A05/MF A01 CSCL 20A

Theoretical and experimental studies were conducted to determine the noise transmission into acoustic enclosures ranging from simple rectangular box models to full scale light aircraft in flight. The structural models include simple, stiffened, curved stiffened, and orthotropic panels and double wall windows. The theoretical solutions were obtained by model analysis. Transfer matrix and finite element procedures were utilized. Good agreement between theory and experiment has been achieved. An efficient acoustic add-on treatment was developed for interior noise control in a twin engine light aircraft. Author

**N85-30769\*** # Bionetics Corp., Hampton, Va.  
**DATA ON NOISE ENVIRONMENTS AT DIFFERENT TIMES OF DAY AROUND AIRPORTS**

J. M. FIELDS Jun. 1985 56 p refs  
(Contract NAS1-16978)  
(NASA-CR-172612; NAS 1.26:172612) Avail: NTIS HC A02/MF A01 CSCL 20A

Sources of information about noise environments at different times of the day at civilian and military airports are identified. Information about movements of scheduled flights are available in machine readable form from the Official Airline Guide. Information about permanent noise monitoring sites is readily obtained from individual airports. Limited data on the timing of flights are available at centralized locations for military airports. An examination of scheduled flights at commercial airports leads to the conclusion that differences between daytime and nighttime noise levels (measured in Equivalent Continuous Noise Level, LEQ) vary from 7 to 15 decibels. Data from 128 permanent noise monitoring sites at 11 airports are also examined. Differences between daytime and nighttime noise levels at these 128 noise monitoring sites vary from 3 to 17 decibels (LEQ). Preliminary analyses suggest that accurate estimates of time-of-day weights could not be obtained from conventional social surveys at existing airports. Author

**N85-30771\*** # Modern Analysis, Inc., Ridgewood, N. J.  
**DESIGN OF SIDEWALL TREATMENT OF CABIN NOISE CONTROL OF A TWIN ENGINE TURBOPROP AIRCRAFT**

R. VAICAITIS and M. SLAZAK Dec. 1983 88 p refs  
(Contract NAS1-16117)  
(NASA-CR-172245; NAS 1.26:172245) Avail: NTIS HC A05/MF A01 CSCL 20A

An analytical procedure was used to predict the noise transmission into the cabin of a twin engine general aviation aircraft. This model was then used to optimize the interior A weighted noise levels to an average value of about 85 dBA. The surface pressure noise spectral levels were selected utilizing experimental flight data and empirical predictions. The add on treatments considered in this optimization study include aluminum honeycomb panels, constrained layer damping tape, porous acoustic blankets, acoustic foams, septum barriers and limp trim panels which are isolated from the vibration of the main sidewall structure. To reduce the average noise level in the cabin from about 102 kBA (baseline) to 85 dBA (optimized), the added weight of the noise control treatment is about 2% of the total gross takeoff weight of the aircraft. R.J.F.

**N85-30773\*** # Army Construction Engineering Research Lab., Champaign, Ill.

**OPERATIONAL NOISE DATA FOR THE LACV-30 AIR CUSHION VEHICLE Final Report**

P. SCHOMER Mar. 1985 25 p  
(Contract IAO-A4105)  
(AD-A154063; CERL-TR-N-85/04) Avail: NTIS HC A02/MF A01 CSCL 20A

Operational data for the LACV-30 air cushion vehicle were gathered and developed into sound exposure level vs distance curves. These data are available for the Army Environmental Hygiene Agency (AEHA) to use in developing noise zone maps for LACV-30 operations in support of the Army Installation Compatible Use Program (ICUZ). ICUZ defines Hand use compatible with various noise levels and establishes a policy for achieving such uses. Although the Army classifies the LACV-30 as an amphibious vehicle, an examination of its noise characteristics and operations showed it most closely resembles a helicopter. Thus, the methodology for gathering rotary wing aircraft data was used. Measurements of LACV-30's passby runs over water at various distances and speeds were similar in concept to flyover and flyby measurements for helicopters, and the land maneuver measurements corresponded most nearly to a helicopter's hover measurements. GRA

**N85-30776\*** # Federal Aviation Administration, Washington, D.C.  
Office of Environment and Energy.

**AVIATION NOISE EFFECTS**

J. S. NEWMAN and K. R. BEATTIE Mar. 1985 117 p  
(AD-A154319; AD-E301685; FAA-EE-85-2) Avail: NTIS HC A06/MF A01 CSCL 20A

This report summarizes the effects of aviation noise in many areas, ranging from human annoyance to impact on real estate values. It also synthesizes the findings of literature on several topics. Included in the literature were many original studies carried out under FAA and other Federal funding over the past two decades. Efforts have been made to present the critical findings and conclusions of pertinent research, providing, when possible, a bottom line conclusion, criterion or perspective. Issues related to aviation noise are highlighted, and current policy is presented. Specific topics addressed include: annoyance; Hearing and hearing loss; noise metrics; human response to noise; speech interference; sleep interference; non-auditory health effects of noise; effects of noise on wild and domesticated animals; low frequency acoustical energy; impulsive noise; time of day weightings; noise contours; land use compatibility; and real estate values. This document is designed for a variety of users, from the individual completely unfamiliar with aviation noise to experts in the field. GRA

**N85-31913** Cornell Univ., Ithaca, N.Y.

**IMPULSIVE NOISE DUE TO TRANSONIC BLADE-VORTEX INTERACTIONS Ph.D. Thesis**

S. B. CHANG 1985 173 p  
Avail: Univ. Microfilms Order No. DA8504496

Two mechanisms cause helicopter impulsive noise. High-speed compressibility noise is almost fully understood, but blade-vortex interaction noise is not yet well understood. The phenomenon of blade-vortex interactions on full scale helicopters is shown to be fundamentally associated with transonic flow phenomenon which can be modeled as two-dimensional. A numerical approach was followed to simulate the two-dimensional blade-vortex interactions. Based on the LTRAN2 code which computes the low-frequency, unsteady, small disturbance velocity potential for transonic flow, a modified version--VTRAN2--was developed to calculate the near-field potential of the blade-vortex interaction. Dissert. Abstr.

## SOCIAL SCIENCES

Includes social sciences (general); administration and management; documentation and information science; economics and cost analysis; law and political science; and urban technology and transportation.

**N85-30962\*** Gellman Research Associates, Inc., Jenkintown, Pa.

**THE ECONOMICS OF PRIVATE SECTOR R AND D DECISIONMAKING IN AERONAUTICS**

20 Dec. 1984 101 p refs Sponsored by NASA (NASA-CR-176007; NAS 1.26:176007) Avail: NTIS HC A06/MF A01 CSCL 05A

Information which can be used in planning to insure commercial research and technology programs which are complementary to internally financed private sector activities are presented. The main concern is to identify the characteristics of productive projects in which firms are unlikely to invest. It is shown that: (1) if it is difficult to assess the commercial relevance of an R&D project or it is characterized by high technical risk, or a relatively long payback period, private funding will be unlikely; and (2) if a project is large relative to the size of the firm, it is unlikely to be funded in the early stages of the R&D process. Firms tend to underinvest in projects with these characteristics. E.A.K.

**N85-30964#** Executive Office of the President, Washington, D. C. Office of Science and Technology Policy.

**NATIONAL AERONAUTICAL R AND D GOALS: TECHNOLOGY FOR AMERICA'S FUTURE**

Mar. 1985 10 p  
Avail: NTIS HC A02/MF A01

Aeronautical research and development goals, particularly in the areas of subsonics, supersonics, and transatmospherics, are discussed. Boundary layer control, flight control, powder metallurgy, and composite aircraft structures are among the areas identified as requiring development. R.J.F.

**N85-30969# RAND Corp., Santa Monica, Calif.  
COST AND SCHEDULE IMPLICATIONS OF MULTINATIONAL COPRODUCTION**

M. D. RICH, W. L. STANLEY, J. L. BIRKLER, and M. E. VAIANA  
Jul. 1984 12 p  
(AD-A154358; RAND/P-6998) Avail: NTIS HC A02/MF A01 CSCL 05A

Coproduction, or international collaboration during production of a major weapon system, is one of the more complex forms of multinational cooperation, and the Rand Corporation has completed a comprehensive investigation into some widely held beliefs about such arrangements. The purpose of the analysis was to assess the impact of coproduction on acquisition costs and schedules and to identify ways to maximize its advantages while sidestepping its pitfalls. (For details of this Air Force-sponsored study, see Michael Rich, William Stanley, John Birkler, and Michael Hesse, Multinational Coproduction of Military Aerospace Systems, Rand Corporation, R-2861-AF, October 1981). Researchers were particularly interested in determining whether European collaborative programs are credible guideposts for predicting the outcomes of U.S.-European programs, whether collaborative programs experience more schedule slippage than do unimational programs, and whether coproduction imposes a cost penalty on the United States. The Rand team examined a wide variety of unimational, U.S.-European, and European collaborative aerospace development and production programs, both completed and ongoing, including the largest and most complex U.S.-European collaborative effort to date, the F-16 fighter aircraft program.

GRA

**N85-31090** International Civil Aviation Organization, Montreal (Quebec).

**SEARCH AND RESCUE SERVICES FOR INTERNATIONAL CIVIL AVIATION**

C. F. DONNADIEU *In* CNES Satellite Aided Search and Rescue. Expt. Results and Operational Prospects p 17-21 1984 In FRENCH

Avail: CEPADUES, Toulouse

The establishment, maintenance, and running of aviation search and rescue (SAR) services are outlined. The SAR services in Africa are mentioned. Evolution and trends in SAR are discussed. Author (ESA)

**N85-31098** Centre National d'Etudes Spatiales, Toulouse (France).

**SEARCH AND RESCUE IN CANADA**

R. C. DAGENAIS *In* its Satellite Aided Search and Rescue. Exptl. Results and Operational Prospects p 81-85 1984 Partly in ENGLISH and FRENCH

Avail: CEPADUES, Toulouse

Geographical factors influencing search and rescue (SAR) missions in Canada are outlined. The objects of SAR missions (mostly private aircraft and vessels) are summarized. The SAR aircraft and surface vehicles are described. Author (ESA)

**N85-31099** Rescue Coordination Center, Bodoe (Norway).

**THE NATIONAL SEARCH AND RESCUE (SAR) NEEDS AND ORGANIZATION IN NORWAY**

K. OYERE *In* CNES Satellite Aided Search and Rescue. Exptl. Results and Operational Prospects p 87-89 1984

Avail: CEPADUES, Toulouse

Norwegian air, sea, and mountain rescue services are described. Organization, resources, and international cooperation are outlined. Author (ESA)

**N85-31323#** San Antonio Air Logistics Center, Kelly AFB., Tex.  
**AIR FORCE BID SAMPLE TESTING**

S. W. HALWES *In* American Defense Preparedness Association Proc. of the Electron. Test Equipment Div.'s Ann. Program Rev. of Electron. Test Equipment Ind. Response to Emerging Defense Requirements p 83-94 1984

Avail: NTIS HC A09/MF A01 CSCL 05A

It is the policy of the DOD and the Air Force to procure electronic test equipment when it will meet AF requirements. A piece of equipment which meet the requirements is subjected to bid sample lab testing. The SA-ALC Kelly, AFB bid sample program is outlined and the policies, channels, and testing associates with it are discussed. E.R.

**N85-32021** Elliott-Automation Space and Advanced Military Systems Ltd., Camberley (England). Weapons Systems Div.

**THE DEVELOPMENT OF COMPLEX SYSTEMS**

D. ODWYER 1984 31 p Presented at Marconi 84, 30 Oct. - 1 Nov. 1984

Avail: Issuing Activity

The need for a well structured and carefully controlled development program to reduce the risks inherent in the development of complex systems is discussed. Aspects of the Tornado avionics development program are illustrated.

Author (ESA)

**N85-32022#** National Aeronautical Lab., Bangalore (India).

**R AND D PROGRAMMES AT THE NATIONAL AERONAUTICAL LABORATORY Annual Report, 1982 -1983**

1983 204 p refs  
(AR-22) Avail: NTIS HC A10/MF A01

Research and development activities at the National Aeronautical Laboratory in India are discussed. Topics in aerodynamics, materials science, propulsion, systems engineering, aircraft structures, and windpower utilization are covered.

## 17 SOCIAL SCIENCES

**N85-32027#** National Aeronautical Lab., Bangalore (India).

### **R AND D ACTIVITIES OF THE SYSTEMS ENGINEERING DIVISION**

C. S. RANGAN *In its* R and D Programmes at the Natl. Aeron.

Lab. p 95-109 1983 refs

Avail: NTIS HC A10/MF A01

Various activities of the Systems Engineering Division of the National Aeronautical Laboratory are discussed. Strain gauge based transducers, wind vane transducers, fiber optic accelerometers, airborne computers, active control, vibration test systems, and telemetry systems are described. R.J.F.

**N85-32031#** Defense Systems Management School, Fort Belvoir, Va.

### **PROGRAM MANAGER: THE JOURNAL OF THE DEFENSE SYSTEMS MANAGEMENT COLLEGE, VOLUME 14, NUMBER 2, MARCH-APRIL 1985**

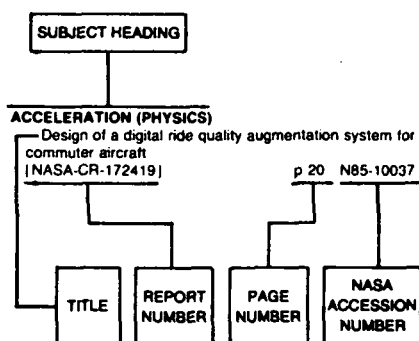
R. W. BALL Apr. 1985 48 p refs

(AD-A154219; DSMC-64) Avail: NTIS HC A03/MF A01; also

avail: SOD HC \$3.00 CSCL 05B

Articles in this journal of the Defense Systems Management College include: Streamlining the Advanced Tactical Fighter; The Soldier Machine Interface; Designing Military System Command Restructures a Program for Affordability; and Tailoring Specifications for Advanced Medium Short Take-off and Landing Transport (AMAST) Program. GRA

## Typical Subject Index Listing



The subject heading is a key to the subject content of the document. The title is used to provide a description of the subject matter. When the title is insufficiently descriptive of the document content, the title extension is added, separated from the title by three hyphens. The (NASA or AIAA) accession number and the page number are included in each entry to assist the user in locating the abstract in the abstract section. If applicable, a report number is also included as an aid in identifying the document. Under any one subject heading, the accession numbers are arranged in sequence with the AIAA accession numbers appearing first.

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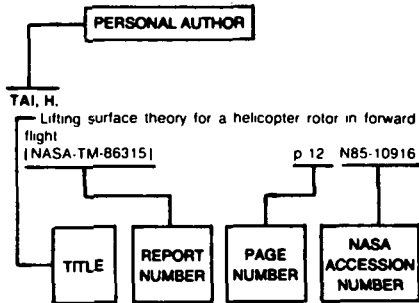
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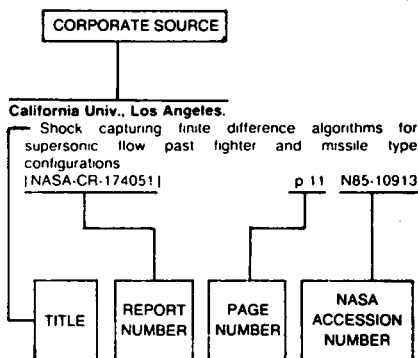
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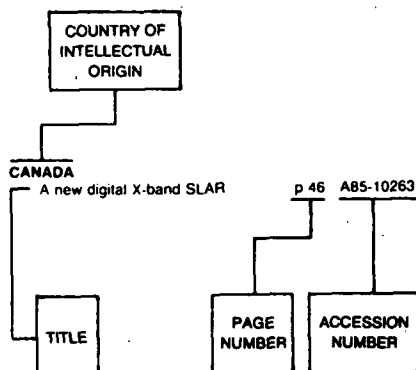
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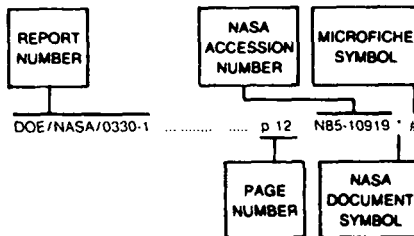


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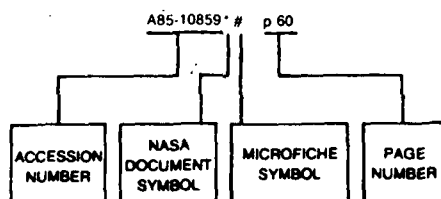
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